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DEFENSE LOGISTICS AGENCY
APPAREL RESEARCH NETWORK (ARN) PROGRAM
SIZE SELECTION FOR ARNSCAN
FINAL TECHNICAL REPORT

For

ARN Short Term Project (DDFG – T2 - P5)

Submitted to:

Defense Logistics Agency
Attention: DLA-MMPRT, Julie Tsao
8725 John J. Kingman Road
Suite 2533, Box 31-510
Ft. Belvoir, VA 22060-6221

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Name of PI	Carol Ring
E-mail	<u>Cring@spsu.edu</u>
Phone	770-528-3173
Fax	770-528-7556
Address	Southern Polytechnic State University Apparel & Textile Engineering Technology 1100 South Marietta Parkway Marietta, Georgia 30060-2896

Table of Contents

EXECUTIVE SUMMARY	1
1.0 INTRODUCTION.....	4
1.1 PURPOSE, SCOPE AND OBJECTIVES.....	4
1.2 METHODOLOGY AND SOURCES	4
1.3 SAN DIEGO MARINE CORP RECRUIT DEPOT FIELD TEST	5
2.0 TROUSER SIZE SELECTION	6
2.1 CRITICAL MEASUREMENTS	6
2.2 PRELIMINARY SIZE SELECTION RULES	6
2.3 RECRUIT MEASUREMENT DATA ANALYSIS.....	7
3.0 DRESS COAT SIZE SELECTION	10
3.1 CRITICAL MEASUREMENTS	10
3.2 PRELIMINARY SIZE SELECTION RULES	10
3.3 RECRUIT MEASUREMENT DATA ANALYSIS.....	11
4.0 DRESS SHIRT SIZE SELECTION	13
4.1 CRITICAL MEASUREMENTS	13
4.2 PRELIMINARY SIZE SELECTION RULES	13
4.3 RECRUIT MEASUREMENT DATA ANALYSIS.....	14
5.0 ADDITIONAL CLOTHING ITEMS SIZE SELECTION.....	18
5.1 CRITICAL MEASUREMENTS	18
5.2 PRELIMINARY SIZE SELECTION RULES	18
6.0 MEASUREMENT EXTRACTION TOOL DEVELOPMENT	19
7.0 PRELIMINARY SIZE SELECTION ANALYSIS.....	23
7.1 TROUSER ANALYSIS PERFORMED FEBRUARY 1999	23
7.2 TROUSER ANALYSIS PERFORMED MARCH 1999	27
7.3 COAT ANALYSIS PERFORMED APRIL 1999.....	32
8.0 SIZE ISSUE WITH ARNSCAN AT MCRD	33
8.1 ARNSCAN SESSION AT MCRD SAN DIEGO MAY, 1999.....	33
8.2 ARNSCAN SESSION AT MCRD SAN DIEGO MAY, 1999 (MODIFICATIONS).....	43
8.3 ARNSCAN SESSION AT MCRD NOVEMBER, 1999.....	45
8.4 ARNSCAN SESSION WITH WBX SCANNER AT MCRD FEBRUARY, 2000	50
8.5 ARNSCAN SESSION WITH WBX SCANNER AT MCRD FEBRUARY - MARCH, 2000	60
8.6 ARNSCAN SESSION WITH WBX SCANNER AT MCRD FEBRUARY - MAY, 2000	63
9.0 REPEATABILITY TEST RESULTS – SIZE SELECTION	72
10.0 ERROR CHECKING ALGORITHM	76
11.0 SCAN DATA REVIEW FOR PATTERN CHANGE	79
12.0 SIZE SELECTION RULE METHODOLOGY	82
12.1 COAT RULE METHODOLOGY	82
12.2 TROUSER RULE METHODOLOGY.....	87
13.0 SCAN DATA COMPARED TO DSCP TARRIFF	91

13.1	MARINE CORP MEN'S DRESS COAT	91
13.2	MARINE CORP MEN'S DRESS TROUSERS	94
13.3	MARINE CORP MEN'S LONG SLEEVE SHIRT	97
14.0	STATISTICAL SIZE ISSUE ANALYSIS	101
15.0	CONCLUSIONS.....	102
16.0	APPENDIX.....	103
16.1	MEASUREMENT DEFINITIONS	103
16.2	TROUSER GARMENT AND BODY MEASUREMENT TABLE	104
16.3	COAT GARMENT AND BODY MEASUREMENT TABLE	105
16.4	LONG SLEEVE SHIRT GARMENT AND BODY MEASUREMENT TABLE	106

EXECUTIVE SUMMARY

This report documents the work of Southern Polytechnic State University (SPSU) as part of a consortium of contractors in the Defense Logistics Agency Apparel Research Network. The consortium project was coded DDFG-T2P5 and titled "Automating Information Extraction from 3D Body Scans". The research performed at SPSU was in support of efforts by Beecher Research Company (Dayton, OH) and Cyberware, Inc. (Monterey, CA) in their endeavor to develop a software system that could issue acceptable sizes for military apparel using measurements extracted from a 3-D full body scanner.

Beecher Research Company contracted Carol Ring of SPSU as a consultant from December 1997 through May 1998 to investigate the methodology for generating size selection tables for the U.S. Marine Corp Dress Uniform. SPSU as a partner in the Apparel Research Network submitted a proposal to continue this research from July 1998 through December 2000. Ring's work is referenced in the Final Technical Report submitted by Beecher in April 1999 and Cyberware in May 2000 but is the foundation of the continued work and therefore is incorporated into this report.

Working with Beecher and Cyberware, Apparel Research Network Partners, SPSU developed algorithms for size selection, analyzed and evaluated measurement data from ARNScan, and supported the implementation of the scanner and software at the San Diego Marine Corp Recruit Depot (MCRD). The ARNScan system measures recruits and issues garments deemed acceptable by MCRD-SD in accuracy and speed.

The sections of this report describe the methodology of size selection generation as well as examples of rules generated for the male Marine Corp recruit. The following is a brief overview of the report by section.

Section 1.0 INTRODUCTION

The following components were the basis for the size selection rule generation methodology and will be discussed throughout this report:

- Selection of critical measurements
- Table of body measurements
- Table of garment finished dimensions
- Fit intent from service fit manual if available
- Alterations limits and order of preference
- Documented perception of fit intent from service staff and tailors
- Development of ease limit range for each critical measurement
- Generation of size selection table for range of sizes

Section 2.0 TROUSER SIZE SELECTION

The critical measurements determined for the trouser were the waist, seat, inseam, and height. The trouser rules were developed based on the ease range and the alteration range allowed for each size. Recruit issue data was collected at MCRD in April of 1998 for analysis and was used for the baseline during rule generation.

Section 3.0 DRESS COAT SIZE SELECTION

The critical measurements determined for the coat were chest, across shoulder, waist, seat, and height. The size selection rules were developed using the across shoulder as the first size indicator and the chest secondary. The rules were written based on measurement ranges and were ordered in sequence of preference taking alterations into consideration. The initial recruit data gathered at MCRD was used for the baseline during rule generation.

Section 4.0 DRESS SHIRT SIZE SELECTION

The critical measurements determined for the shirt were neck and across shoulder. Size selection rules were generated based on the ease range and the limited alterations allowed on the shirt. The initial recruit data gathered at MCRD was used for the baseline during rule generation.

Section 5.0 ADDITIONAL CLOTHING ITEMS SIZE SELECTION

Ring met with the design group in Albany to discuss additional items requested by MCRD. Rules were generated for the following items.

- Battle Dress Uniform Coat – issued by chest and height
- Battle Dress Uniform Trouser – issued by waist and inseam
- Quarter length sleeve shirt - issued same size as long sleeve shirt, same fit criteria, same basic pattern
- All weather man coat - issued same size as service coat
- Sweater- based primarily on chest measurement
- Marine General Purpose Trunks – issued by waist
- Cap/garrison and frame- issued by head measurement

Section 6.0 MEASUREMENT EXTRACTION TOOL DEVELOPMENT

Measurement tools were developed and modified for improvement throughout the process. Each new or revised tool was analyzed using the database previously developed. This allowed the researchers to make comparisons of measurements and sizes issued from the same scan data. Therefore an accurate picture of which tool gave the best results.

Section 7.0 PRELIMINARY SIZE SELECTION ANALYSIS

A larger data base of scan files were collected at MCRD in January 1999 and was utilized to review the current measurement extraction tools and the preliminary size selection rules. The actual sizes issued at MCRD were recorded as well as the sizes that ARNScan would have recommended for each recruit. This information was compared and analyzed by several criteria in the process of determining the best outcomes.

Section 8.0 SIZE ISSUE WITH ARNSCAN AT MCRD

In May of 1999 the ARNScan system was utilized at MCRD to issue the first try-on size. The recruits were followed by research staff through the process of being first observed for fit by the fitting staff at MCRD and then by the tailor who would determine the alterations to be made. As much as possible feedback from the fitter and the tailor were documented as well as the final size garment the recruit was issued. This session provided one more component for reevaluation of the measurements extracted and also the size selection rules.

Section 9.0 REPEATABILITY TEST RESULTS – SIZE SELECTION

Preliminary repeatability tests were performed in the initial phase of development of measurement extraction tools. It was decided by program management and research partners to perform a second repeatability test at the current stage of software and system development. The test was performed at Cyberware by research staff in validation of the system and scanning process as the data indicates.

Section 10.0 ERROR CHECKING ALGORITHM

Researchers evaluated the possibility of error checking a measurement by utilizing a secondary measurement for that scan data set. The across shoulder was the measurement to be tested and the chest was used as the secondary measurement. The research indicated that this methodology was of value and should be investigated further in future project work.

Section 11.0 SCAN DATA REVIEW FOR PATTERN CHANGE

Use of the scan database for pattern review was deemed a possibility in the future. A test data set was utilized with a hypothesis for change and new size selection processed. It was determined at this time with the wide range of alterations being performed that there was not evidence from this size data set to indicate that a pattern change would improve size selection or number of alterations.

Section 12.0 SIZE SELECTION RULE METHODOLOGY

The marine dress clothing items size selection tables were generated taking into consideration the design intent, tailoring and alteration information, and effectiveness based on actual sizes issued at MCRD. The steps in generating rules and priority of rules are outlined in tables in an effort to provide a more complete understanding of the methodology.

Section 13.0 SCAN DATA COMPARED TO DSCP TARRIFF

Approximately 2000 scan sizes issued were used as the basis of a comparison of the actual quantity issued by size to the ratio of sizes used by DSCP. The analysis indicated that the larger sizes were issued more frequently than the smaller sizes as compared to the DSCP distribution. This correlated with the trend observed by the researchers which indicated that a larger size was preferred by the fitter and tailor for alteration.

Section 14.0 STATISTICAL SIZE ISSUE ANALYSIS

Size issue data is documented at MCRD for all dress clothing items. A statistical analysis is performed to determine the performance of ARNScan for measurement extraction and size selection. The current summary is included in this report and may also be accessed at www.cyberware.com.

1.0 INTRODUCTION

1.1 Purpose, Scope and Objectives

This project work is defined in the T2P5 Coordination Plan, Section T1.2 Measurement Extraction' generated by Cyberware as coordinator for the 3-D project. The following report describes Southern Polytechnic State University's research efforts in the area of body measurements and fit requirements necessary for size selection rule generation. Southern Polytechnic staff, Carol Ring, conducted the investigation in the area of body specification charts, garment finished dimension charts, alteration requirements, and standards for interpreting size selection for the male Marine dress uniform. The uniform includes a dress coat, long sleeve shirt, and green and blue trousers.

The objective of this research was to generate size selection rule algorithms, which would determine appropriate sizes for the military recruit for Men's Marine Corp dress uniform items. These rules would be imported into the body scan and measurement extraction software system, ARNScan, which was developed as part of the Apparel Research Network (ARN) project. The objective of automatic selection of sizes by ARNScan was to improve the issue time and accuracy at first fit. This was accomplished during the installation of an automated measurement and sizing system, ARNScan, at the U.S. Marine Corp Recruit Depot at San Diego.

1.2 Methodology and Sources

There are several components that effect the fit of clothing items but the most quantifiable are the body measurements and the garment measurements. The fit criteria is based on the difference between these two measurements, a term referred to as *fit ease*. A minimum amount of ease is required for the person who is wearing the garment to have an acceptable level of comfort and mobility based on the use of the garment. The balance of the ease is determined by the designer during the development of the pattern used in constructing a specific garment. Generally that standard is carried across the spectrum of sizes manufactured. For instance if the standard ease for the chest is 2" on a 36 then it is also 2" on the size 48. This standard would allow for the appearance of the garment to be consistent regardless of the size the person is wearing. In actuality, no two people have the identical fit because each individual has a unique body. Specific measurements on the garment are used for fit criteria however other characteristics and body measurements may give the wearer a slightly different appearance. This is the reason that although the garment has been manufactured to standard ease, the acceptable ease is a plus and minus range from this standard.

The following components were the basis for the size selection rule generation methodology and will be discussed throughout this report:

- Selection of critical measurements
- Table of body measurements
- Table of garment finished dimensions
- Fit intent from service fit manual if available
- Alterations limits and order of preference
- Documented perception of fit intent from service staff and tailors
- Development of ease limit range for each critical measurement
- Generation of size selection table for range of sizes

The sources for information regarding Marine Corp dress uniforms were fit manuals, military specifications for selected garments, garment patterns, Albany Marine Corp (MC) design group, staff at MCRD San Diego, and the tailors responsible for dress uniform alterations.

The measurements determined to be critical to size selection were selected from the Critical Garment Dimension list generated through several meetings of the T2P5 partners and are listed in the following table. It was determined that body measurement charts are not available for the Marine uniform, therefore with input from the designers at the Marine base in Albany one was created. The patterns and the military specifications for each of the garments were used in generating the final finished dimension chart. The ease limits were developed incorporating input from the fit manual, MC designers, tailors, and MCRD staff.

The fit requirements were defined throughout the process. They were developed using the fit manual provided by the Marine designers, input from the designers, alteration tailors, and research staff. This was an ongoing effort. The measurement evaluations cover three versions of ARNScan: 7.3 released summer 1998, 8.0 released November 1998, and 9.0 released February 1999. As new information was developed through the analysis of the scan data the size selection rules were updated. The size selection tables were generated in a format for import into the ARNScan software.

Garment Measurement Chart for Size Selection

Dress Uniform Trousers	Long Sleeve Shirt	Dress Uniform Coat
Hip (Seat) Waist Height Inseam	Neck Across Shoulder Chest Center Back Sleeve Length	Across Shoulder Chest Waist Seat Height

1.3 San Diego Marine Corp Recruit Depot Field Test

The initial body scan data utilized during the SPSU size selection development was gathered at MCRD, San Diego. Up to the time of this field test in 1998, the Cyberware scanner and ARNScan software had only been used in controlled laboratory conditions.

At first fit of the dress uniform (T19), four weeks into their training, the recruits are fit for dress uniforms. This scanning session acquired a database useful for further development and testing of size selection tables generated by SPSU, and also provided an opportunity for Ring to record size and alteration information concerning the uniform issued to the scanned recruits.

Ring traveled to San Diego for the scanning of Marine recruits during their first fit (T19) of dress uniforms April, 1998. She worked with the MCRD tailor contractors to understand the fit and alteration process. This included measuring altered uniforms for differences from stock size specifications. The information collected was combined with other information concerning sizes issued, alterations, second fit changes, and ARNScan measurements for the recruits. All of this data was used by Ring to modify and test new size selection tables, as well as to comment on the quality of measurements provided by ARNScan for size selection.

A more detailed description of the planning process and initial field test is provided in the Final Technical Report, "AUTOMATING INFORMATION EXTRACTION FROM 3D BODY SCAN DATA" prepared by Beecher Research Company.

2.0 TROUSER SIZE SELECTION

2.1 Critical Measurements

The critical measurements determined for the trouser were waist, seat, inseam, and height. The trousers were being issued by taking the waist measurement and selecting the size. The garment size name references the waist. The seat measurement was determined to be the most critical measurement because altering the garment in that area was more difficult and increase allowances were minimal. The garment seat measurement was developed from the military pattern and linked to the waist size in a table. The size selection rules were developed using the seat as the first size selection indicator forcing the waist to be altered first and the seat secondary. The garment was constructed with an outlet (extra fabric) in the seatseam at the waist to allow ease in alteration for increase or decrease.

The height range is given in the military specifications for each of the lengths available in the tariff. The inseam was determined for each length. The height was determined to be the first selector for length and the inseam range was developed to be the second indicator. Lists of measurement definitions, body measurements, and finished garment measurements for the tariff range are included in the appendix for reference.

2.2 Preliminary Size Selection Rules

Size selection rules were developed based on the ease range and the alteration range allowed for each size. The following is an example of the preliminary size selection range chart and rule table.

Waist and Seat Range Chart (only 3 sizes for example)

Waist and Seat Range Chart (only 5 sizes for example)													
Garment	Stock Range			Allowed Alterations			Stock Range			Allowed Alterations			
	Size	- ½	Waist	+ ½	- 1.75	Waist	+1.75	- 1/2	seat	+ 1/2	-1.00	seat	+1.00
33	31.5	32	32.5	30.25	32	33.75		38.5	39	39.5	38	39	40
34	32.5	33	33.5	31.25	33	34.75		39.5	40	40.5	39	40	41
35	33.5	34	34.5	32.25	34	35.75		40.5	41	41.5	40	41	42

Size Selection Rule Table (one seat size only with multiple waist ranges)

Garment Dimensions	Garment Waist Size	Garment Waist Ease		ARNScan Waist Range		ARNScan Seat Range		Garment Seat Ease		Garment Seat
-1 Alter Waist & Seat	33	1.75	2.75	30.25	31.25	39.50	40.50	1.50	2.50	42
Alter Waist	34	1.50	2.75	31.25	32.50	39.50	40.50	2.50	3.50	43
Stock	34	0.50	1.50	32.50	33.50	39.50	40.50	2.50	3.50	43
+1 No Alter	35	0.50	1.50	33.50	34.50	39.50	40.50	3.50	4.50	44
+1 Alter Waist	35	-0.75	0.50	34.50	35.75	39.50	40.50	3.50	4.50	44
+2 Alter Waist & Seat	36	-0.75	0.25	35.75	36.75	39.50	40.50	4.50	5.50	45

2.3 Recruit Measurement Data Analysis

The initial men's green and blue marine trouser data analysis started in June and continued through July 98. The garment fit for approximately 65 recruits from T19, April 1998 was determined based on garment finished dimensions after alteration. The fit was calculated by subtracting the ARNScan body measurement from the appropriate garment dimension. The difference is defined as *fit ease*. The following analysis references the sample rule table in the previous section.

The ARNScan body measurements were used to generate the amount of drop from waist to seat. For example the difference between the waist of 33 and the seat of 40 for the size 34 garment is 7 inches. The standard provided by the pattern is 7 inches for all sizes. The following are the results of the drop analysis:

Drop Analysis	Minimum	3.4	Maximum	8.9
	Mode	5.8	Median	6.8

As noted the min of 3.4 is much smaller than the standard of 7 as is the maximum of 8.9 much larger. The mode of 5.8 and the median of 6.8 are much closer to the target of 7. It would be expected that the recruits that have drops further away from the target would require the most alterations.

The ARNScan body measurements were used to calculate the actual fit ease in the first fit garments from T19. The standard target for waist ease is 1 and the target for seat ease is 3. The following are the results of the ease analysis:

Actual Fit Ease Seat	Minimum	0.8	Maximum	5.9
	Mode	3.4	Median	3.6

Actual Fit Ease Waist	Minimum	-1.8	Maximum	3.4
	Mode	1.1	Median	1.5

As noted the minimum of .8 is much smaller than the standard seat ease of 3 as is the maximum of 5.9 larger. The mode of 3.4 and the median of 3.6 are close to the target, which indicates that the larger portion of the sample is close to the target. The waist ease minimum of -1.8 and maximum of 3.4 are a wide spread from the target of 1. But the mode of 1.1 and the median of 1.5 indicate that the larger portion of the sample tend to be close to the target. This data was generated for consideration in generating the ARNScan ease range charts. The garment finished dimension chart and *fit ease standard* were used to generate the body measurement chart during the first phase of research. These charts are the basis for determining the ease range chart used to create ARNScan size selection rules. The standard measurements for the base size are as follows:

- waist finished measurement 34 inches
- body measurement 33 inches
- fit ease 1inch
- seat finished measurement 43 inches
- body measurement 40 inches
- fit ease 3 inches

The fit ease target and the statistical analysis of the actual fit ease were used as the basis for creating a range of fit ease for each size in the tariff. Standard design practices and the analysis of the fit ease issued in San Diego were considered when determining the minimum and maximum. The range determined to be acceptable is as follows:

	Minimum	Standard	Maximum
Waist range	½"	1"	1 ½"
Seat range	2 ½"	3"	4 ½"

The seat body measurement range for the stock 34 garment is 39.5 – 40.5. The seat measurement is the critical measurement, therefore the first measurement to determine the size selection rule. The seat was determined to be the critical measurement because there is much more flexibility in alterations at the waist. Notice that these size selection rules all have the 34 seat range. The second criteria is the waist. After determining the seat range, find the waist range that the body measurement would fall in. The waist range and seat range end points were determined using the range charts. For example the stock 34 waist range is the standard range from the chart. This would be the standard fit for a stock waist of 34.

If the body waist measurement were 1" larger than stock and the seat was in the rule set range for stock 34, the size selected would be 35 or +1 no alter. This recruit basically has a seat measurement for a 34 garment and a waist measurement of a 35. Notice the ease range is 0.5 – 1.5 and does not require an alteration. The next waist range was determined by the alteration range end points and would require an alteration. The balance of the rules were generated with the same methodology.

The issued size at MCRD was compared to the size selected using ARNScan rules with the following preliminary results:

Same size 37
+/- one size 27
+/- two size 5

The rules were determined to simulate very closely the size selection process presently in place. The ARNScan size selection is based on given ranges and many times only a small amount of change in the measurement would allow the selection to be +/-1 one size. Where selecting size based on fit perception only has more variability. The fit ease was calculated for the MCRD issue size and the ARNScan issue size. It was then determined from data provided by MCRD, the number of alterations that were performed on the issued size in comparison to how many would be required for each if issued the ARNScan size. The summary results are as follows:

	MCRD Issue		ARNScan Issue	
Alterations	Seat	Waist	Seat	Waist
First Fit	33	57	6	34
Second Fit	13	15		

The process in determining alterations appears to have some inconsistency. Some size issues and alterations may happen based on which sizes are in stock at the given time. Cases as examples are outlined in the following summary list. ARNScan will use the same criteria for fit from recruit to recruit, thus minimizing alterations required and providing a more consistent fit. Individual recruit information was reviewed. Examples in the following list include sizes issued the same, one size different, and two sizes different.

MCRD issue size 36 ARNScan issue size 36

- Waist altered at MCRD.
- ARNScan requires waist alteration.

MCRD issue size 36 ARNScan issue size 38

- Alterations were performed on the seat and waist at MCRD.
- The ARNScan size issued of 38 fit the seat and was only altered in the waist.

MCRD issue size 33 ARNScan issue size 32

- Alterations were performed on the seat and waist at MCRD.
- The ARNScan size issued fit without any alterations.

MCRD issue size 35 ARNScan issue size 34

- No alterations performed on the 35 issued by MCRD but the fit ease was not within the acceptable range.

- The size 34 issued by ARNScan did not require any alterations and was within the ease range ease.

MCRD issue size 34

ARNScan issue size 36

- Alterations performed on first and second fit for a total of 4 alterations
- ARNScan issue of 36 fit the recruit appropriately with no alterations.

3.0 DRESS COAT SIZE SELECTION

3.1 Critical Measurements

The critical measurements determined for the coat were chest, across shoulder, waist, seat, and height. The coats were being issued by taking the chest measurement and selecting the size. The garment size name references the chest. The across shoulder measurement was determined to be the most critical measurement because the coat hangs from the shoulder and because altering the shoulder is very difficult. The garment across shoulder measurement was developed from the military pattern and linked to the chest size in a table. The size selection rules were developed using the across shoulder as the first size selector, the chest second, the waist third, and then the seat.

The height range is given in the military specifications for each of the coat lengths available in the tariff. The height range was modified slightly based on the issue data collected at MCRD. A list of measurement definitions, body measurements, and finished garment measurements for the tariff range are included in the appendix for reference.

3.2 Preliminary Size Selection Rules

Size selection rules were developed based on the ease range and the alteration range allowed for each size. The fit was calculated by subtracting the ARNScan body measurement from the appropriate garment dimension. The difference is defined as *fit ease*. The following is an example of the preliminary size selection rule table. Each rule indicates the ease range. This is the allowed range for ease minus alterations when they are allowed.

The rules are ordered in sequence of preference. The body measurements would be compared to the rules starting with Rule 1 of all sizes before going on to Rule 2 if there was no match. The second rule as indicated has a wider range of ease therefore, also a wider range of body measurement size. Rule 3 has the maximum alteration allowance incorporated into the ease.

Green Service Coat Ease Range Chart (only 3 sizes for example)

Coat Size	Stock Range			Stock Range			Allowed Alterations		
	- 1/8	Across Shld	+ 1/8	- 1/2	chest	+ 1/2	-4.00	chest	+2.00
39	16.875	17.000	17.125	38.5	39	39.5	35	39	41
40	17.125	17.250	17.375	39.5	40	40.5	36	40	42
41	17.375	17.500	17.625	40.5	41	41.5	37	41	43

Coat Size	Stock Range			Allowed Alterations			Stock Range			Allowed Alterations		
	- 1/2	waist	+ 1/2	-5.00	waist	+2.00	- 1/2	seat	+ 1/2	-5.00	seat	+2.50
39	31.5	32	32.5	27	32	34	38.5	39	39.5	34	39	41.5
40	32.5	33	33.5	28	33	35	39.5	40	40.5	35	40	42.5
41	33.5	34	34.5	29	34	36	40.5	41	41.5	36	41	43.5

Size Selection Rules for Green Service (3 size sample)

Rule 1	Across Shoulder			Chest			Waist			Seat		
	Ease .75 - 2.00			Ease 2.0 - 6.0			Ease 2.0 - 7.5			Ease 2.0 - 7.0		

39	16.00	18.00	17.25	35.00	41.00	39.00	27.00	34.50	32.50	34.00	41.00	39.00
40	16.25	18.25	17.50	36.00	42.00	40.00	28.00	35.50	33.50	35.00	42.00	40.00
41	16.50	18.50	17.75	37.00	43.00	41.00	29.00	36.50	34.50	36.00	43.00	41.00

Rule 2	Across Shoulder			Chest			Waist			Seat		
	Ease .50 - 2.25			Ease 1.0 - 7.0			Ease 1.0 - 8.5			Ease 1.0 - 8.0		

39	15.75	18.00	17.50	34.00	41.00	40.00	26.00	34.50	33.50	33.00	41.00	40.00
40	16.00	18.25	17.75	35.00	42.00	41.00	27.00	35.50	34.50	34.00	42.00	41.00
41	16.25	18.50	18.00	36.00	43.00	42.00	28.00	36.50	35.50	35.00	43.00	42.00

Rule 3	Across Shoulder			Chest			Waist			Seat		
	Ease .50 - 2.50			Ease 1.0 - 8.0			Ease 1.0 - 9.5			Ease 1.0 - 9.0		

39	15.50	18.00	17.50	33.00	41.00	40.00	25.00	34.50	33.50	32.00	41.00	40.00
40	15.75	18.25	17.75	34.00	42.00	41.00	26.00	35.50	34.50	33.00	42.00	41.00
41	16.00	18.50	18.00	35.00	43.00	42.00	27.00	36.50	35.50	34.00	43.00	42.00

3.3 Recruit Measurement Data Analysis

The garment fit for approximately 65 recruits from T19, April 1998 was determined based on garment finished dimensions after alteration. The fit was calculated by subtracting the ARNScan body measurement from the appropriate garment dimension. The difference is defined as *fit ease*.

The ARNScan body measurements were used to generate the amount of *drop*. The standard provided by the pattern is 7 inches from *chest to waist* and also 7 inches from *waist to seat*. The following are the results of the drop analysis:

Drop Analysis	Chest to Waist		Waist to Seat	
	Minimum	2.4	Minimum	3.4
	Maximum	9.3	Maximum	8.9
	Mode	4.2	Mode	5.8
	Median	6.4	Median	6.8

As noted the minimum of 2.4 and 3.4 are much smaller than the standard of 7. The maximum of 9.3 and 9.9 are much larger than the standard of 7. The mode of 5.8 on the waist to seat drop is closer to 7 than the chest to waist drop of 4.2. The median of 6.4 and 6.8 are much closer to the target of 7. All of the data suggests the ratio of waist to seat is closer to the standard than the ratio of chest to waist. It would be expected that the recruits that have drops further away from the target would require the most alterations.

The mode of 4.2 on the chest to waist drop indicates that the difference between chest and waist runs smaller than the expected. Further analysis is indicated for the chest and waist.

The ARNScan body measurements were used to calculate the actual fit ease in the first fit garments from T19. The standard target ease is 1 for across shoulder, 2 for chest, 2.5 for waist, and 2 for seat when using raw body measurements. The trouser reduces the waist ease to 1.5 with a result of 1, 2, 1.5, and 2 inches respectively. The following are the results of the ease analysis:

Actual Fit Ease Across Shoulder (Target 1")	Minimum Mode	-.53 1.58	Maximum Median	2.49 1.23
Actual Fit Ease Chest (Target 2")	Minimum Mode	.88 4.47	Maximum Median	6.00 3.85
Actual Fit Ease Waist (Target 2.5")	Minimum Mode	-.60 4.40	Maximum Median	4.40 2.70
Actual Fit Ease Seat (Target 2")	Minimum Mode	.80 3.40	Maximum Median	5.90 3.60

The mode and median of across shoulder, chest, waist, and seat are larger than the target. This was taken into consideration when creating the ease range allowed on each measurement.

The fit ease target and the statistical analysis of the actual fit ease were considered in generating a range of fit ease for each size in the tariff. Standard design practices and the fit perception indicated from the San Diego data were utilized in determining the minimum and maximum. The range determined to be acceptable is as follows:

Ease Range	Minimum	Standard	Maximum
Across Shoulder	.5	1.0	2.0
Chest	1.5	2.0	4.0
Waist (trouser-1)	2.0(-1)1.0	2.5(-1)1.5	4.5(-1)3.5
Seat	1.5	2.0	4.0

The alteration range was determined by information gathered from the fit manual and the San Diego tailoring process in relationship to possible alteration amounts at specific points on the garment.

The results of size selection with ARNScan body measurement compared to the MCRD issue size is as follows:

Same size	25
+/- 1	20
+/- 2	13
+/- 3	4

The present coat rule version is not simulating as closely the MCRD size selection as the trouser rule. Four anthropometric body measurements in different combinations make the rule generation much more complex. Recruits where the size comparison was more than one size off was reviewed to determine if any other factors that are readily visible from ARNScan contributed to the size selected at MCRD.

4.0 DRESS SHIRT SIZE SELECTION

4.1 Critical Measurements

The critical measurements determined for the shirt were neck and across shoulder. The shirts were being issued by taking the neck measurement and selecting the size. The garment size name references the neck. The neck measurement was determined to be the most critical measurement because the ease is critical in the appearance of the garment. The garment across shoulder measurement was developed from the military pattern and linked to the neck size in a table. The size selection rules were developed using the neck as the first size selector and the across shoulder as the second.

The sleeve length was determined by using one half of the across back and adding to that the distance from the shoulder to 1" from the joint of the thumb. A list of measurement definitions, body measurements, and finished garment measurements for the tariff range are included in the appendix for reference.

4.2 Preliminary Size Selection Rules

Size selection rules were developed based on the ease range and the limited alterations allowed. The following is an example of the preliminary size selection rule table. The size 15.5 rules are used for this example. Each rule indicates the ease range. The rules are ordered in sequence of preference. The body measurements would be compared to the rules starting with Rule 1 of all sizes before going on to Rule 2 if there was no match. The second rule as indicated has a wider range of ease therefore, also a wider range of body measurement size.

ARNScan Size Selection Rules for Men's Long Sleeve Shirt										
Garment Size	Garment Neck	Neck	Ease	Neck	Range	Garment Shoulder	Across Shoulder	Ease	Shoulder	Range
15.50	16.00	1.25	1.75	14.25	14.75	18.50	1.75	2.25	16.25	16.75
15.50	16.00	1.00	2.00	14.00	15.00	18.50	1.25	2.50	16.00	17.25
15.50	16.00	0.75	2.25	13.75	15.25	18.50	0.75	2.75	15.75	17.75
15.50	16.00	0.75	2.50	13.50	15.25	18.50	0.25	3.00	15.50	18.25

4.3 Recruit Measurement Data Analysis

The garment fit for approximately 65 recruits from T19, April 1998 was determined based on garment finished dimensions after alteration. The fit was calculated by subtracting the ARNScan body measurement from the appropriate garment dimension. The difference is defined as *fit ease*.

The ARNScan body measurements were used to determine the range of difference between neck and shoulder. The standard of fit determined from the pattern data established that a recruit wearing a size 15.5 stock has a 15.5" neck and 17.25" shoulder. This indicates a difference of 1.75 inches from neck to shoulder. This was determined to remain consistent as grading on the neck and the shoulder was .50" for all sizes. The following are the results of this analysis:

Neck and Shoulder Difference

Maximum	4.56
Minimum	.61
Mode	2.64
Median	2.54

The maximum of 4.56 indicates that one case was approximately five sizes larger in the shoulder than the neck $((4.56 - 1.75) / .50)$. This is the most extreme of cases. This recruit's measurements indicated that a size 14 would appropriately fit the neck and a 16.5 would fit his shoulders. The recruit was issued a size 15. The standard fit ease in the neck was increased as the fit ease in the shoulder was decreased. Alterations of the long sleeve shirt are limited to shortening the sleeve. Therefore, the best available stock fit is chosen.

The minimum of .61 indicates that one case was smaller on the shoulder than expected for the shoulder. Assuming the neck as the standard the recruit's shoulders were smaller based on the fit profile. The recruit's measurements indicated that a size 15.5 would appropriately fit the neck but the shoulder required a size 14. The recruit was issued a 15.5 therefore allowing more ease in the shoulder than the standard. Most

cases would be resolved in this way because the neck ease standard is only .50". Reducing the neck size is not acceptable in these cases.

The mode of 2.64" and the median of 2.54" indicate that the majority of recruits differ in neck to shoulder size approximately 1 -1 ½ sizes. These recruits will fit in the stock size within acceptable ease allowances.

The ARNScan body measurements were used to calculate the actual fit ease in the first fit garments from T19. The standard target ease is .50" for the neck and 1.25" for across shoulder. The following are the results of the ease analysis:

Actual Fit Ease Neck	Minimum	.70	Maximum	2.39
Pattern .5"	Mode	1.75	Median	1.58
Actual Fit Ease Across Shoulder	Minimum	-.40	Maximum	3.26
Pattern 1.25"	Mode	1.77	Median	1.61

The mode and median of neck and across shoulder ease are larger than the target. The long sleeve shirt is fitted over an undershirt; therefore, this was taken into consideration when creating the ease range allowed on the neck measurement. For example, the circumference of a neck of 15.5" is increased to 16.25" when a layer of clothing 1/8" thick is worn. The thickness of the set seam of the undershirt collar was used for this analysis. This would indicate that approximately ½ - ¾ " ease could be used by the layering of garments. The allowed neck fit ease is .50" to 1". The mode of 1.75 and median of 1.58 are acceptable ease allowances taking into consideration the reduction of ease by the undershirt (1.75 minus .75).

The mode and median for the across shoulder are approximately .50" larger than the pattern standard of 1.25". The long sleeve shirt is worn over the undershirt; therefore, the fit ease is near standard at 1.61" and 1.77".

The preliminary shirt rule version size selection compared to MCRD issue size resulted in the following:

Same size	24
- 0.50	16
+0.50	24
- 1.00	1
+1.00	1

Sizes issued within one size (.50) are being considered acceptable. Many of these were very near the limits of the range, and therefore were borderline falling into the next size. This is due to a precise mathematical system of rules using measurement data only for size prediction and therefore, also being more consistent in methodology. Recruits where the size comparison was more than one size off were reviewed to determine if there are any other factors that are readily visible from ARNScan that are contributing to the size selected at MCRD.

The following tables describe graphically the range for the rules used in shirt size selection. If the measurement for the shoulder (ex. 15" neck) did not fall in the previous range, the next range becomes wider as indicated by the bar chart. The second chart shows the collapsing of the rules for the 15" neck indicating the minimum and maximum ends of the shoulder range. It also shows the 14.0 and 14.5 to demonstrate that other sizes follow this same methodology.

Example:

Neck measurement 15.0.

Bar indicates each rule shoulder range where 15.0" fits in the allowed neck range.

Double vertical line indicates width of shoulder range.

Neck 15.0	14.00	14.25	14.50	14.75	15.00	15.25	15.50	15.75	16.00	16.25	16.50	16.75	17.00	17.25	17.50	17.75	18.00	18.25	18.50	18.75	19.00	19.25	19.50	19.75	20.00
Rule 1 15.5																									
16.0																									
Rule 2 15.5																									
16.0																									
16.5																									
Rule 3 15.5																									
16.0																									
16.5																									
Rule 4 15.5																									
16.0																									
16.5																									
17.0																									

Example:

The following table indicates the width of all the rules for neck 14.0, 14.5, and 15.0.

Bar indicates the range of shoulder measurements that are included in the rule sets where the neck range includes 15.0.

Neck measurements of 14.0 and 14.5 are also illustrated. Note as the neck measurement increased the shoulder range shifted accordingly.

Shoulder measurements across top and neck on left side.

Neck	14.00	14.25	14.50	14.75	15.00	15.25	15.50	15.75	16.00	16.25	16.50	16.75	17.00	17.25	17.50	17.75	18.00	18.25	18.50	18.75	19.00	19.25	19.50	19.75	20.00
13.50																									
13.75																									
14.00																									
14.25																									
14.50																									
14.75																									
15.00																									
15.25																									
15.50																									

5.0 ADDITIONAL CLOTHING ITEMS SIZE SELECTION

5.1 Critical Measurements

Ring met with the design group in Albany to discuss additional items requested by MCRD. The following additional items were discussed:

- Battle Dress Uniform Coat – issued by chest and height
- Battle Dress Uniform Trouser – issued by waist and inseam
- Quarter length sleeve shirt - issued same size as long sleeve shirt, same fit criteria, same basic pattern
- All weather man coat - issued same size as service coat
- Sweater- based primarily on chest measurement
- Marine General Purpose Trunks – issued by waist
- Cap/garrison and frame- issued by head measurement

5.2 Preliminary Size Selection Rules

The dress coat table was modified to accommodate the tariff for the all weather coat. The dress coat was issued by one inch chest increments and the over coat size changed every two inches. The long sleeve shirt rules were modified slightly for the short sleeve tariff. Not all sizes were available in the short sleeve. The BDU coat, BDU trouser, sweater, trunks, and caps were issued based on one primary body measurement, therefore were linear in form. The focus of the research was on dress clothing items, which are much more complex in the fit and size selection.

A preliminary size selection table was generated for all additional bag items. The following is the summary of size selection tables imported into ARNScan for the May 99 scan sessions.

BDU Trouser Rules

Measurements: Waist, Inseam

BDU Coat Rules

Measurements: Chest, Stature

Trouser Rule, Green and Blue

Measurements: Seat, Waist, Stature, Inseam

Coat Rule, Service Green

Measurement: Across Shoulder, Chest, Waist, Seat

Shirt Rule, Long Sleeve

Measurement: Neck, Across Shoulder, Chest, Sleeve Length

Shirt Rule, Quarter Sleeve

Measurement: Neck, Across Shoulder, Chest, Sleeve Length

All- Weather Coat Rule

Measurement: Across Shoulder, Chest, Waist, Seat

Wool Sweater/Dress Sweater

Measurement: Chest

Utility Cap

Measurement: Head Measurement

Frame and Garrison Cap

Measurement: Head Measurement

Trunks, General Purpose

Measurement: Waist

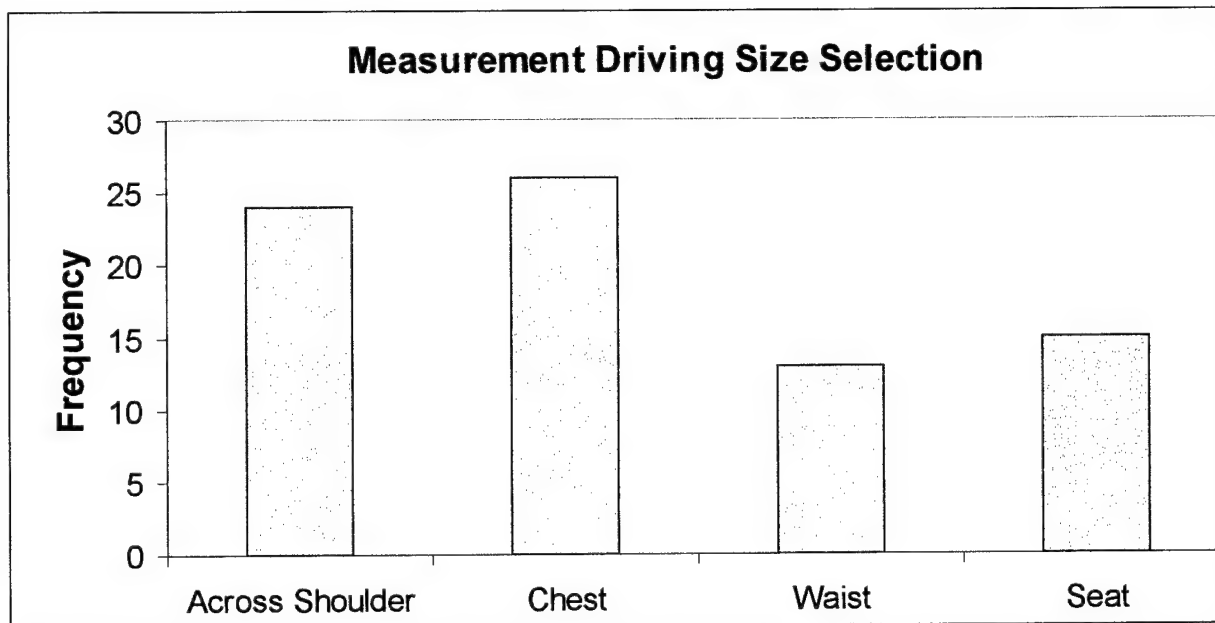
6.0 MEASUREMENT EXTRACTION TOOL DEVELOPMENT

As the investigation and analysis progressed, different measurement extraction tools were developed and the current ones were modified for improvement by the ARN partners. The initial ARNScan software for measurement data extraction was version 7.3 (v.7.3) and was used for preliminary size selection rules. The revised software is referred to as version 8.0 (v.8). Measurement data was reviewed by SPSU researchers during this process and analyzed for the impact on the measurement and also the resulting changes in the size issue as compared to the MCRD size. As the software was modified, measurement data comparisons were made on v.7.3, v.8, and v.9. The resulting size selections were also compared.

The body scan data collected by the Cyberware scanner at the Marine Corp base was processed with different versions of the measurement extraction software that contained modified or new measurement extraction tools. This allowed the researchers to evaluate the same recruit scan with measurements extracted differently. The across shoulder and sleeve length measurement extraction tools were the focus of the changes in v.8 software. New across shoulder and sleeve length measurements extracted with v.8 of ARNScan were provided by Beecher for evaluation. The shoulder function appeared to provide similar data to the previous tool. This new measurement data was used to refine the shirt rules.

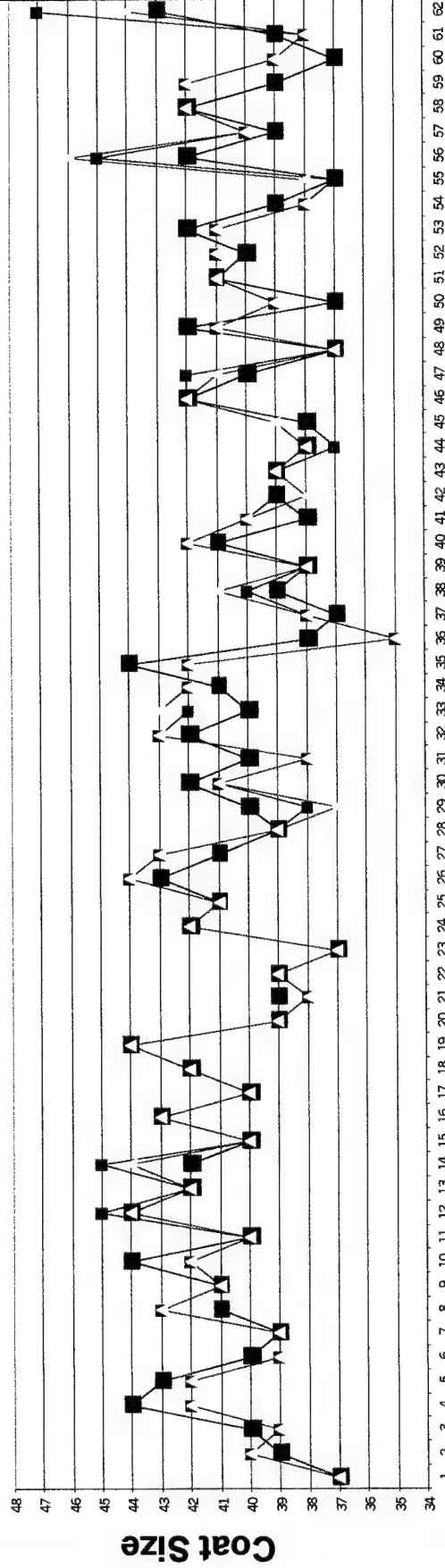
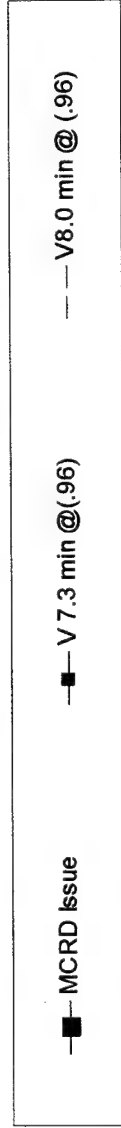
Version 8 ARNScan across shoulder measurements were received from Beecher. These measurements were extracted by several options as were V.7.3 originally. The initial version included several angles toward the neckline and also a minimum function. Of the seven sets of data reviewed in V.7.3, the minimum function was determined to best simulate traditional methods of measurement. This was also the determination with the V 8.0 data. The across shoulder data was reduced by a factor due to the location point at the shoulder joint (acromion). The factor determined best was .96, the same as with the V 7.3 data.

A more detailed discussion of measurement extraction tool development can be found in the final reports submitted by Beecher and Cyberware. The following tables display the coat size selection summary data. As the size selection was being performed, the driving measurement was noted. The following table displays the frequency of each of these measurements. As expected the frequency of the across shoulder and chest were high. A larger portion of the sizes was selected because of a significantly large or small waist and seat than expected.



This table consists of a comparison of MCRD issue size to V.7.3 and V.8.0 sizes selected. The dark blue data symbols indicate the MCRD size issued. The table indicates that in many cases where the size selection by ARNScan differed from MCRD, V.7.3 and V.8 were fairly consistent.

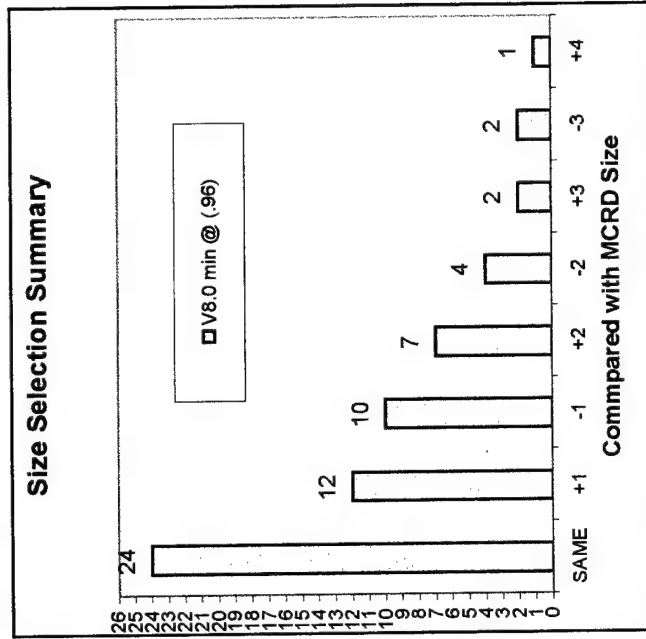
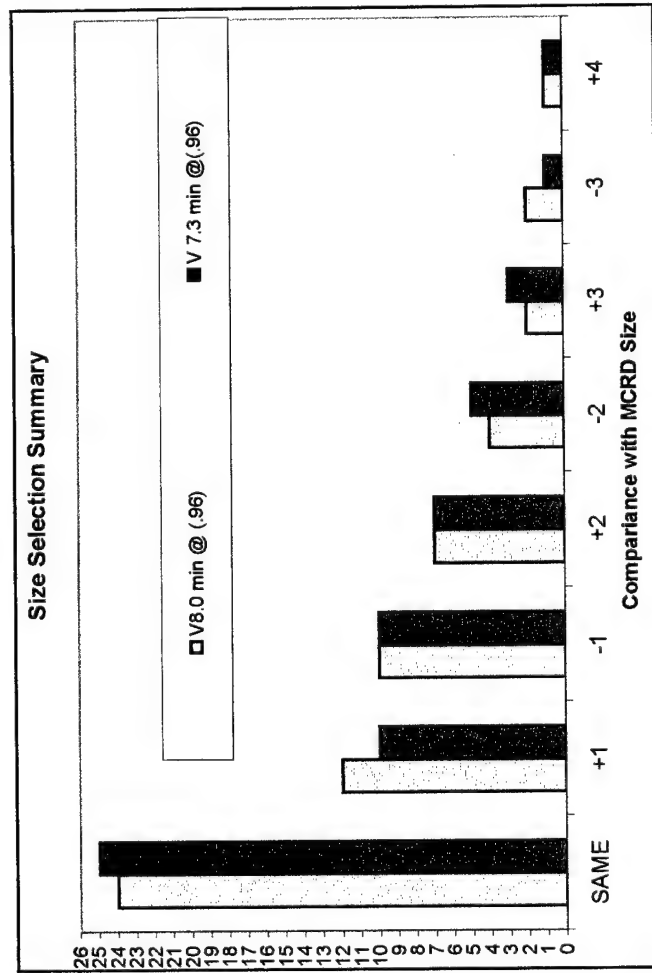
Coat Size Selection



Recruit Sample

The following charts were created using the summary data of the size selection performed. The chart on the left is a display of V.8.0 size selection and V.7.3 size selection as compared to the MCRD size issued. As a whole, the V.8.0 was as close to the MCRD sizes as V.7.3.

The second chart indicates the summary numbers for the current version of size selection, Version 8.0.



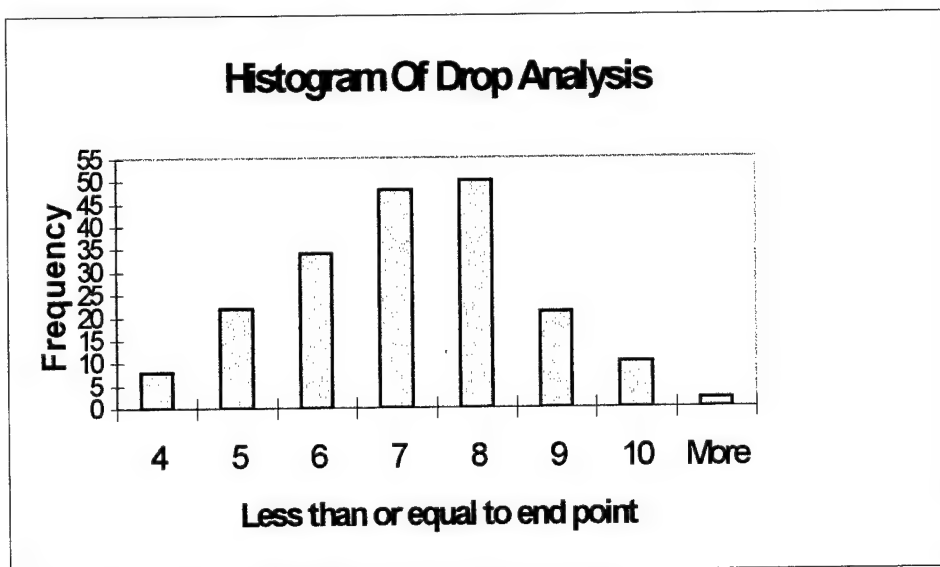
7.0 PRELIMINARY SIZE SELECTION ANALYSIS

The first draft of the size selection rules for the Marine Corp men's service uniform which includes the coat, trouser, and long sleeve shirt were provided to Cyberware and imported into the ARNScan system. The rules were next evaluated at SPSU for improvement of size selection and for additional rules to capture all extreme measurements.

7.1 Trouser Analysis Performed February 1999

An analysis was performed on trouser size selection for 195 recruits. The ARNScan body measurements were used to generate the amount of drop from waist to seat. The standard provided by the pattern is 7 inches. The following are the results of the drop analysis:

Drop Analysis	Minimum 3.1	Maximum 10.4
	Mode 7.2	Median 6.8



Bin Frequency	
<=	
4	8
5	22
6	34
7	48
8	50
9	21
10	10
More	2

The drop analysis results indicate that some recruits have an extremely small or large difference in the waist to seat ratio. The standard is 7 inches compared to 3.1 for the minimum and 10.4 for the maximum. Data collected in San Diego indicates that all of the recruits being examined were issued a garment from the stock supply, which was altered to fit these extremes. Seven of the 195 subjects did not fit in the ranges determined for Version 1 of the trouser size selection rules. At that time they were noted to be special. Upon further analysis a modification of one rule and the generation of two additional rules captured the measurements for these seven and allowed ARNScan to issue sizes that were appropriate.

The ARNScan sizes selected were compared to the issued size at MCRD. The ease (difference between garment finished measurement and the body measurement) was calculated for the 195 recruits. This is the determining criterion for appropriate fit. This data was used to determine which was the best fit before alterations, ARNScan or MCRD. The evaluation is based on only the body measurements, seat and waist, therefore the visual observation of the tailor or fit analyst is not considered in the following analysis.

The MCRD and the ARNScan issue size were compared and provided the following information. Garments issued one size (one inch) larger or smaller are being considered acceptable. The size selection rules are based on exact mathematical intervals and 1/10 of an inch in a measurement can result in a size up or down being selected. As the following table indicates, 94 % of the ARNScan sizes issued as compared to MCRD were acceptable.

Issue Difference	Quantity	Per Cent of 195
Same size	96	49.23
- 1	67	34.36
+ 1	20	10.26
- 2	8	04.10
+ 2	4	02.05

MCRD and ARNScan issued the same size for 49% of the 195 recruits. The size issue that fell within the +/- 1 accounted for 44% of the 195. The ease measurement was determined and evaluated for each of these 87 recruits. It was determined that the size issued by ARNScan was generally better or equally as good a fit as the MCRD issue size.

The 6 % or 12 issues that were out of the acceptable range were investigated in more detail. Ease ranges are .5-1.5 inches on the waist and 2.5-3.5 inches on the seat as stock or after alterations. The results indicate that size selection rules should not be changed. Based on the measurement data only, the sizes selected by ARNScan were appropriate even though they did not coincide with the sizes actually issued. The following recruit sample data tables show examples of ARNScan issue verses MCRD.

Service Trousers – Sample Size Difference of –2 and +2							ARNScan	Issue	MCRD	Issue
	Body Measurement		Trousers Size Issue				Ease	Ease	Ease	Ease
	Seat	Waist	SPSU	MCRD	Diff Size	Drop	Waist	Seat	Waist	Seat
Recruit 1	40.3	32.9	34	36	-2	7.4	1.09	2.69	3.09	4.69
Recruit 2	36.3	28.6	30	32	-2	7.7	1.38	2.70	3.38	4.70
Recruit 3	39.4	32.5	33	35	-2	7.0	0.52	2.55	2.52	4.55
Recruit 4	39.4	30.1	32	34	-2	9.3	1.92	1.59	3.92	3.59
Recruit 5	37.1	32.6	32	34	-2	4.5	-0.60	3.91	1.40	5.91
Recruit 6	37.3	29.8	31	33	-2	7.5	1.24	2.72	3.24	4.72
Recruit 7	39.60	31.1	33	35	-2	8.5	1.90	2.40	3.90	4.40
Recruit 8	38.10	31.9	33	35	-2	6.2	1.10	3.90	3.10	5.90
Recruit 9	43.9	36.6	38	36	2	7.2	1.39	3.14	-0.61	1.14
Recruit 10	43.90	35.9	38	36	2	8.0	2.10	3.10	0.10	1.10
Recruit 11	39.40	35.0	35	33	2	4.4	0.00	4.60	-2.00	2.60
Recruit 12	40.60	34.9	36	34	2	5.7	1.10	4.40	-0.90	2.40

Recruit 1, 2, 3, 5, 6, 8:

- Size issued by ARNScan fit as stock or with minor alteration based on body measurements.
- The Size issued by MCRD appears to be much larger than standard ease expected therefore requiring large alterations.

Recruit 9, 10, 11, 12:

- Size issued by ARNScan fit closer to standard with minor alteration.
- Size issued by MCRD appeared to be much smaller than standard ease.

Recruit 4,7:

- Size issued by ARNScan or MCRD would need major alterations. Drop was 9.3 and 8.5 which are far from the expected of 7.

Service Trousers – Sample Size Difference of –1							ARNScan	Issue	MCRD	Issue
	Body Measurement		Trousers Size Issue				Ease	Ease	Ease	Ease
	Seat	Waist	SPSU	MCRD	Diff Size	Drop	Waist	Seat	Waist	Seat
Recruit 13	37.5	31.6	33	34	-1	5.9	1.43	4.52	2.43	5.52
Recruit 14	40.3	34.1	35	36	-1	6.2	0.94	3.72	1.94	4.72
Recruit 15	35.9	29.0	30	31	-1	6.9	1.02	3.09	2.02	4.09
Recruit 16	36.9	30.0	31	32	-1	6.8	0.96	3.15	1.96	4.15
Recruit 17	36.5	30.3	31	32	-1	6.3	0.72	3.46	1.72	4.46
Recruit 18	40.7	33.7	35	36	-1	7.0	1.34	3.33	2.34	4.33
Recruit 19	35.7	29.6	31	32	-1	6.1	1.39	4.25	2.39	5.25
Recruit 20	39.4	31.5	33	34	-1	7.8	1.46	2.63	2.46	3.63
Recruit 21	38.1	31.5	32	33	-1	6.6	0.46	2.89	1.46	3.89
Recruit 22	36.6	27.3	30	31	-1	9.3	2.68	2.43	3.68	3.43
Recruit 23	37.5	33.5	33	34	-1	4.1	-0.46	4.48	0.54	5.48
Recruit 24	37.9	31.3	32	33	-1	6.5	0.66	3.13	1.66	4.13
Recruit 25	41.2	34.4	35	36	-1	6.8	0.59	2.82	1.59	3.82
Recruit 26	40.0	30.9	33	34	-1	9.1	2.13	2.04	3.13	3.04

Recruit 13, 14, 15, 16, 17, 18, 19, 20:

- Size issues by ARNScan fit as stock or with minor alteration based on body measurements.
- The size issued by MCRD appears to be much larger than standard ease expected therefore requiring large alterations.

Recruit 21, 23, 24, 25:

- Size issued by ARNScan or MCRD could need alterations. Either size would work.

Recruit 22, 26:

- Size issued by ARNScan or MCRD would require major alterations. Drop was 9.3 and 9.1 requiring an alteration on the waist and the seat.

Service Trouser – Sample Size Difference of +1							ARNScan	Issue	MCRD	Issue
	Body Measurement		Trouser Size Issue				Ease	Ease	Ease	Ease
	Seat	Waist	SPSU	MCRD	Diff Size	Drop	Waist	Seat	Waist	Seat
Recruit 27	36.9	29.1	31	30	1	7.8	1.91	3.15	0.91	2.15
Recruit 28	42.2	36.7	37	36	1	5.5	0.31	3.80	-0.69	2.80
Recruit 29	40.9	33.9	35	34	1	6.9	1.06	3.13	0.06	2.13
Recruit 30	42.20	36.0	37	36	1	6.2	1.00	3.80	0.00	2.80
Recruit 31	38.8	30.8	33	32	1	8.0	2.21	3.22	1.21	2.22
Recruit 32	39.2	32.6	34	33	1	6.7	1.44	3.79	0.44	2.79
Recruit 33	42.6	35.3	37	36	1	7.2	1.69	3.44	0.69	2.44
Recruit 34	37.8	28.2	31	30	1	9.6	2.77	2.20	1.77	1.20
Recruit 35	38.9	29.2	32	31	1	9.6	2.79	2.14	1.79	1.14
Recruit 36	42.6	39.4	39	38	1	3.2	-0.37	5.44	-1.37	4.44

Recruit 27, 28, 29, 30:

- Size issued by ARNScan fit as stock or with minor alteration.
- Size issued by MCRD appears to be much smaller than the expected ease therefore requiring alterations.

Recruit 31, 32, 33:

- Size issued by ARNScan required alterations to decrease the waist in some cases.
- Size issued by MCRD appeared to need alterations also. Either size would have worked.

Recruit 34, 35, 36:

- Size issued by ARNScan or MCRD would need major alterations. Drop was 9.6, 9.6, and 3.2. These trousers would need seat and waist alterations either size issued.

The previous analysis of the recruit measurement, fit ease, and sizes issued demonstrates that in many cases more than one size could be issued for the same recruit. The allowed alterations would vary from size issued to size issued. The results

do not demonstrate in most cases that the difference in any size issued was due to error but instead to variability of alterations.

The ARNScan trouser size selection rules perform based on seat measurement first and then waist. This may not always be the case in size selection based on visual observation. Factors such as possible assumption that the recruit will loose weight in the waist area due to training may bias a fit analyst to issue a smaller waist garment than what is needed at the present time. Therefore the size issued by ARNScan and MCRD are different but neither is necessarily wrong.

7.2 Trouser Analysis Performed March 1999

Each new measurement data set extracted by ARNScan was evaluated with the current set of size selection rules for the Marine Corp men's service uniform, which includes coat, trouser, and long sleeve shirt. To date, data from Version 7, 8, and 9 have been generated. Rules were revised to better the outcome if possible and additional rules were added for measurements outside the accepted values. The most current version of size selection rules for trousers was sent to Cyberware in March for importing into ARNScan software. An analysis was performed on trouser size selection for 210 recruits.

The ARNScan sizes selected were compared to the issued size at MCRD. The ease (difference between garment finished measurement and the body measurement) is the determining criterion for appropriate fit. The evaluation is based on only the body measurements, seat and waist, therefore the visual observation of the tailor or fit analyst is not considered in the following analysis.

The MCRD and the ARNScan issue size were compared and provided the following information. The following table shows the comparison of the Version 8 (V8) and Version 9 (V9) results.

Comparison of MCRD Trouser Issue to ARNScan

Issue MCRD Vs ARNScan	Quantity - Version 8		Quantity - Version 9	
Same Size	96	49%	116	55%
-1	67	34%	46	22%
+1	20	10%	38	18%
-2	8	4%	3	1%
+2	4	2%	7	3%
Sum	195		210	

Garments issued one size (one inch) larger or smaller are being considered acceptable. The size selection rules are based on exact mathematical intervals and 1/10 of an inch in a measurement can result in a size up or down being selected. As the table indicates V9 data shows a slight improvement over V8. The most significant change was in the quantity issued the same. Using percentages because the total data available varied from 195 to 210, V9 showed an improvement from 49% to 55%. The

size issue that fell within the +/- 1 accounted for 94% on V8 and 95% on V9 data. Therefore, the final analysis indicates that V9 results are comparable to V8 with slight improvement.

The height (stature) and inseam data from Version 9 ARNScan were used to evaluate the trouser length rules. The data was analyzed by sorting the MCRD length issue and the corresponding ARNScan height measurement. The maximum and minimum range for height and inseam were determined as listed in the following table.

MCRD Height and Inseam Range (V9.0 Data)				
	Inches			
	Height		Inseam	
	Low	high	Low	high
X-Short	None			
Short	62.32	66.50	27.00	30.87
Regular	60.91	70.63	26.77	32.20
Long	65.00	73.35	28.50	35.98
X-long	68.23	76.34	30.24	35.04

The standard provided by the fit manual suggests the following height increments be used in the issue process:

MC Fit Manual Length Range		
LENGTH	Height Range Inches	Inseam Maximum
X-Short	60 – 64	29
Short	65 – 67	31
Regular	68 – 70	33
Long	71 – 73	35
X-Long	73 - up	37

After reviewing the height ranges indicated by MCRD issue, it was determined that the issue process did not utilize the suggested length ranges. The most significant problem with the MCRD ranges was the major overlap. The high end of the short range overlaps the low end of the regular by 6 inches. The same problem occurs with the inseam lengths. The high on the short overlaps the regular by 4 inches and so forth. The overlap of heights made it difficult to use this data to write rules of length assignment.

A comparison of the fit standard height minimum to the MCRD minimum shows that MCRD issue height runs significantly shorter for each length available. The overall analysis of MCRD length issue indicates that the height range for issue is shorter for each length than the fit manual suggested. One assumption could be that the process of issuing a length that would meet the maximum inseam required could most easily be met issuing the lengths longer. The following was determined to be the most accurate rule methodology with the current ARNScan data and MCRD issue analysis.

ARNScan Length Ranges

LENGTH	Height Range Inches
X-Short	0 – 62
Short	62 – 65
Regular	65 – 68
Long	68 – 71
X-Long	71 – 78

The ARNScan size selection rules generated incorporating inseam lengths are described in the following table.

ARNScan Trouser Length Rules

If height and if inseam are:	Length	Height-low	high	Inseam-low	high
Height is 0 – 62 (x-short) and inseam 25 or less issue-	x-short	0	62	0	25
Height is 0-62 (x-short) and inseam is 25-31 go up one length to short.	short	0	62	25.01	31
Height is 62-65 (short) and inseam is 25 – 31 issue-	short	62.01	65	25.01	31
Height is 62-65 (short) and inseam is 31-33 go up one length to regular.	regular	62.01	65	31.01	33
Height is 65-68 (regular) and inseam is 27-33 issue-	regular	65.01	68	27.01	33
Height is 65-68 (regular) and inseam is 33-35 go up one length to long.	long	65.01	68	33.01	35
Height is 68-71 (long) and inseam is 29-35 issue-	long	68.01	71	29.01	35
Height is 68-71 (long) and inseam is 35-37 go up one length to x-long.	x-long	68.01	71	35.01	37
Height is 71-78 (x-long) and inseam is 31-37 issue-	x-long	71.01	78	31.01	37
Height is 0-100 and inseam is 0-100 is special x-long-inseam or height out of the previous ranges.	Sp x-long	0	100	0	100

The rules were generated taking into consideration that MCRD did not issue x-short, that a large portion of the MCRD length issue was longer than expected and was altered by the tailor to the appropriate length. Modifying the rules after collecting more data based on ARNScan size selection can be performed fairly easily at a later date.

The length issue by MCRD was compared to the length issue by ARNScan.

Trouser Length Issue Comparison

ARNScan minus MCRD	Quantity	Accumulative Percentage
Same as MCRD	129	61
-1	43	82
+1	1	82
-2	38	100
Sum	211	

ARNScan issued 129 trouser lengths out of 211 the same as MCRD or 61%. Including the issues within plus or minus one size, ARNScan issued 82% the same as MCRD. There were 38 recruits who were issued 2 lengths shorter by ARNScan even after reducing the height ranges 2 inches. MCRD does not stock all lengths and it could be assumed that they are issuing what is available, usually a longer length than required.

The size selection table was modified to capture measurements that were out of the range of the current rule set. As the rules were generated, the seat measurement remained constant and the waist range was modified to include additional measurement combinations. The following charts demonstrate the range of measurements accommodated by the seat measurement of a standard size 34 trouser. Some of the ranges may seem extreme but were necessary to accommodate the issue process at MCRD. Few specials are ordered, therefore when measurements on a recruit are beyond the normal limits, a garment is issued and altered.

Trousers Mil-T-29452A	Garment	ARNScan Measurement				Garment
	Size	Seat		Waist		Seat
Minus Special	32	39.5	40.5	0.00	29.00	41
-2 Major alterations	32	39.5	40.5	29.00	30.25	41
-1 Alter Waist & Seat	33	39.5	40.5	30.00	31.25	42
Alter Waist	34	39.5	40.5	31.25	32.50	43
Stock	34	39.5	40.5	32.50	33.50	43
+1 No Alter	35	39.5	40.5	33.50	34.50	44
+1 Alter Waist	35	39.5	40.5	34.50	35.75	44
+2 Alter Waist & Seat	36	39.5	40.5	35.75	36.75	45
+3 Major alterations	37	39.5	40.5	36.75	37.75	46
Plus Special	37	39.5	40.5	37.75	100.00	46

Waist on seat of size 34- Size chart in right end column refers to rules in table.																																								
0.0	29	29	29.25	29.5	29.75	30	30.25	30.5	30.75	31	31.25	31.5	31.75	32	32.25	32.5	32.75	33	33.25	33.5	33.75	34	34.25	34.5	34.75	35	35.25	35.5	35.75	36	36.25	36.5	36.75	37	37.25	37.5	37.75	100	Size	
Special																																								32
																																								32
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																																								Special 37

Special rules were introduced into the rule set at the low and high maximum seat range as demonstrated in this table.

[illegible]

The previous analysis of the recruit measurement, fit ease, and sizes issued demonstrates that in many cases more than one size could be issued for the same recruit. The allowed alterations would vary from size issued to size issued. The results do not demonstrate in most cases that the difference in any size issued was due to error but instead to variability of alterations. Further analysis of data collected in the issue process will allow the rules to be modified if necessary.

7.3 Coat Analysis Performed April 1999

The Marine Corp men's service uniform coat size selection rules were evaluated with Version 9 (V9) measurement data. Rules were revised to better the outcome if possible and additional rules were added for measurements outside the accepted values. The most current version of size selection rules for the coat was sent to Cyberware for importing into ARNScan software. An analysis was performed on the coat size selection for 210 recruits.

The ARNScan sizes selected were compared to the issued size at MCRD. The ease (difference between garment finished measurement and the body measurement) is the determining criterion for appropriate fit. The evaluation is based on only the body measurements; therefore the visual observation of the tailor or fit analyst is not considered in the following analysis.

The MCRD and the ARNScan issue size were compared and provided the following information. The following table shows the comparison of the Version 7 (V7), Version 8 (V8) and Version 9 (V9) results.

MARINE MAN'S COAT SIZE SELECTION RULES MIL-C-29424A												
Comparison of MCRD Coat Issue to ARNScan Issue												
	Size Rules V4			Size Rules V4			Size Rules V4			Size Rules V5		
	V7	Accumulative		V8	Accumulative		V9	Accumulative		V9	Accumulative	
0	60	60	32%	58	58	31%	49	49	24%	65	65	31%
-1	30	90		25	83		24	73		34	99	
+1	42	132	69%	40	123	65%	61	134	65%	57	156	75%
-2	9	141		8	131		19	153		12	168	
+2	33	174	92%	38	169	90%	30	183	89%	26	194	93%
-3	3	177		4	173		2	185		4	198	
+3	9	186	98%	10	183	97%	16	201	98%	11	209	100%
-4	0	186		0	183		0	201		0	209	
+4	4	190	100%	5	188	100%	4	205	100%	1	210	100%
-5	0	190		0	188		0	205		0	210	
+5	0	190	100%	0	188	100%	1	206	100%	0	210	100%

The table shows ARNScan coat issue using V7, V8, and V9 data as an accumulative percentage as compared to MCRD. As the table indicates, there was improvement in ARNScan issue due to measurement and rule table improvements.

The size selection rule tables for the service coat, trousers, and long sleeve shirt were modified to cover any probable measurement combinations. This was accomplished by adding additional rule sets to the tables.

8.0 SIZE ISSUE WITH ARNSCAN AT MCRD

8.1 ARNScan Session at MCRD San Diego May, 1999

ARN research partners from Southern Polytechnic (SPSU) and Cyberware conducted three recruit body scanning sessions for uniform size selection in May 1999 at MCRD, San Diego. The preliminary results for May 4, 18, and 25 were analyzed separately and then summarized together. Data were collected on a total of 157 recruits in the month of May.

Items listed on ARNScan ticket:

Trouser	Sweater	Garrison Cap	Frame Service Cap
Shirt	All-Weather Coat	Camouflage Coat	Utility Cap
Coat	Shorts	Camouflage Trouser	

The items are listed by size on an ARNScan issue ticket, which was presented to the recruit at the scanning stage. The ARNScan size selection ticket was used by MCRD staff to issue the "first" garment to be tried on by the recruit for the fitter. Current size selection rules are based on linear and circumference body measurements extracted from ARNScan recruit data.

The focus with this session was on the green service coat, shirt, and trouser. SPSU and Cyberware staff followed the platoon with ARNScan issue tickets through the issue line, fitter evaluation, and tailor alteration fitting. When a garment size issued by ARNScan was determined to need to be changed by the fitter the research staff made an effort to document the reason. Very little information was documented at this stage. There is much activity in the area at this time and the fitters seemed hesitant to share information with the researcher.

The research staff followed the recruits through the process to the tailor fitting. At this point, the final size the recruit was issued was documented on the pick ticket and collected. If possible, the research staff noted on the ticket if the tailor sent a recruit to the fitter for another size. The following analysis was performed using the information from the ARNScan issue ticket, the documented final size issued, and ARNScan body measurements exported for SPSU after the scanning session.

Several areas were identified as those that influenced issues that were not acceptable. The evaluations should also supply information that will allow improvement in the size selection tables.

The process in place at MCRD during May included ARNScan scanning; item first size selection based on ARNScan issue ticket, fitter analysis of garment, and final evaluation by the tailor. The process provides opportunities for the fitter and the tailor to change the issued size. There is variance in the process of skilled personnel determining the best fit by visual perception. Several cases were documented during May in which the fitter changed the initial ARN size and the tailor changed the size back to the original size selected by ARN. The tailor was unaware of the size that ARN had issued. He

made the change based on his visual evaluation. None of the sizes were wrong, only different.

May 4, 1999 ARNScan Session

The results of the May 4 session are detailed in the following table. The first section of the table shows a comparison of the ARNScan size selected to the MCRD final issue size. The zero indicates that the issues were the same, negative numbers indicate ARNScan was smaller, and positive numbers indicate that ARNScan was larger. The second section shows an accumulative percentage based on the total for the scanning session. Sizes issued within +/- one size are being considered acceptable. Many of these are very near the limits of the range of measurements for a specific size and therefore may roll into a different size. Analysis of MCRD issue in these cases indicates that there are inconsistencies, as expected, with visual observation as the method of determining size issue in the borderline cases. Using a precise mathematical system of rules using measurement data only will consistently issue these cases in one direction only. The ARNScan issue was not as accurate as expected based on the results from scan data collected in April 1998 at MCRD.

									May 4, 1999 ARNScan Issue								
Trouser			Coat		Shirt				Trouser			Coat		Shirt			
Size	Length		Size	Length		Size		Sleeve									
0	22	20	13	14	0	25	0	8	0	22	54%	0	13	32%	0	25	61%
-1	5	0	12	0	-0.5	2	-1	11	-1	5	66%	-1	12	61%	-0.5	2	66%
+1	8	19	5	25	0.5	12	+1	0	+1	8	85%	+1	5	73%	0.5	12	95%
-2	1	0	0	0	-1	0	-2	18	-2	1	88%	-2	0	73%	-1	0	95%
+2	2	2	3	2	1	1	+2	0	+2	2	93%	+2	3	80%	1	1	98%
-3	0	0	0	0	-1.5	0	-3	4	-3	0	93%	-3	0	80%	-1.5	0	98%
+3	1	0	4	0	1.5	1	+3	0	+3	1	95%	+3	4	90%	1.5	1	100%
-4	0	0	0	0	-2	0	-4	0	-4	0	95%	-4	0	90%	-2	0	
+4	0	0	2	0	2	0	+4	0	+4	0	95%	+4	2	95%	2	0	
-5	0	0	0	0	-2.5	0	-5	0	-5	0	95%	-5	0	95%	-2.5	0	
+5	1	0	0	0	2.5	0	+5	0	+5	1	98%	+5	0	95%	2.5	0	
-6	0	0	0	0	-3	0	-6	0	-6	0	98%	-6	0	95%	-3	0	
+6	0	0	2	0	3	0	+6	0	+6	0	98%	+6	2	100%	3	0	
-7	0	0	0	0					-7	0	98%	-7	0			0	
+7	0	0	0	0					+7	0	98%	+7	0			0	
-8	0	0	0	0					-8	0	98%	-8	0			0	
+8	1	0	0	0					+8	1	100%	+8	0			0	
Total	41	41	41	41		41		41	41			41				41	

After analysis of the results by SPSU, selected scans were sent to Beecher for further evaluation. It was determined that 5 scans had extraneous points on the circumference of the seat that were included as part of the measurement. This resulted in bad ARNScan size selection for these recruits. The inaccurate seat measurements effected the size issue for the coat and the trouser. The table indicates that 6 trousers were issued more than +/- one size different than MCRD. It also indicates that 11 coats were issued more than +/- one size different than MCRD. The shirt results were better with only 2 garments issued out of the acceptable range. The results were skewed by

inaccurate seat measurements and a few across shoulder measurements were further evaluated. Cyberware performed sensitivity parameter adjustments previous to the second scan session which corrected the seat measurement error.

May 18, 1999 ARNScan Session

The results of the May 18 session are detailed in the following table. As the table indicates, there was improvement in the ARNScan size selection. As mentioned earlier, sensitivity parameters required some adjustment after the May 4 session. The issue and measurement data were analyzed by SPSU.

Trouser				Coat				Shirt				May 18, 1999 ARNScan Issue											
	Size	Length		Size	Length			Size		Sleeve		Trouser			Coat			Shirt					
0	23	34	19	35	0	29	0	19	0	23	52%	0	19	43%	0	29	66%	0	23	66%			
-1	4	0	4	0	-0.5	1	-1	16	-1	4	61%	-1	4	52%	-0.5	1	68%	-1	4	68%			
+1	14	10	15	9	0.5	9	+1	5	+1	14	93%	+1	15	86%	0.5	9	89%	+1	15	89%			
-2	0	0	3	0	-1	0	-2	4	-2	0	93%	-2	3	93%	-1	0	89%	-2	0	89%			
+2	3	0	1	0	1	5	+2	0	+2	3	100%	+2	1	95%	1	5	100%	+2	1	100%			
-3	0	0	1	0	-1.5	0	-3	0	-3	0		-3	1	98%	-1.5	0		-3	0				
+3	0	0	1	0	1.5	0	+3	0	+3	0		+3	1	100%	1.5	0		+3	0				
-4	0	0	0	0	-2	0	-4	0	-4	0		-4	0		-2	0		-4	0				
+4	0	0	0	0	2	0	+4	0	+4	0		+4	0		2	0		+4	0				
-5	0	0	0	0	-2.5	0	-5	0	-5	0		-5	0		-2.5	0		-5	0				
+5	0	0	0	0	2.5	0	+5	0	+5	0		+5	0		2.5	0		+5	0				
-6	0	0	0	0	-3	0	-6	0	-6	0		-6	0		-3	0		-6	0				
+6	0	0	0	0	3	0	+6	0	+6	0		+6	0		3	0		+6	0				
-7	0	0	0	0					-7	0		-7	0					-7	0				
+7	0	0	0	0					+7	0		+7	0					+7	0				
-8	0	0	0	0					-8	0		-8	0					-8	0				
+8	0	0	0	0					+8	0		+8	0					+8	0				
	44	44	44	44				44		44			44						44				

The trouser was issued 93% within the acceptable range of +/- one size. Only 3 trousers were issued out of the acceptable range as compared to 6 on the previous session. In many of these cases, the measurement data indicates that ARNScan size issue is correct. We cannot document when a particular size is out of stock, therefore cannot determine the reason for the difference in issue size.

The coat was issued 86% within the acceptable range of +/- one size. This is a good improvement over the previous session at 73%. After analyzing the data several scans were sent to Beecher for review. There did not appear to be the problem with the seat measurement that was identified in the May 4 session. The measurement generally in question was the across shoulder. This is the most difficult measurement to determine accurately. The recruit posture has been changed and also the measurement extraction tool since the April 1998 session. All scans in question are being evaluated to see if the variance in posture may be effecting the across shoulder measurement.

The shirt was issued at 89% within the acceptable range of +/- one size. The same nine recruits were issued larger coats and shirts by ARNScan because of large across shoulder measurements. If the across shoulder is the most extreme measurement, it

will usually drive the size selection up on the coat and shirt. In analyzing the data, the coat and shirt issues are compared to validate the assumptions made.

May 25, 1999 ARNScan Session

The results of the May 25 session are detailed in the following table. A total of 72 recruits were scanned during this session. The issuing process was the same as in the previous two sessions.

									May 25, 1999 ARNScan Issue								
Trouser			Coat		Shirt				Trouser			Coat			Shirt		
Size	Length		Size	Length	Size		Sleeve										
0	38	50	14	57	0	34	0	42	0	38	53%	0	14	19%	0	34	47%
-1	12	2	25	0	-0.5	6	-1	15	-1	12	69%	-1	25	54%	-0.5	6	56%
+1	18	20	12	15	0.5	24	+1	14	+1	18	94%	+1	12	71%	0.5	24	89%
-2	2	0	12	0	-1	0	-2	0	-2	2	97%	-2	12	88%	-1	0	89%
+2	2	0	5	0	1	6	+2	1	+2	2	100%	+2	5	94%	1	6	97%
-3	0	0	0	0	-1.5	0	-3	0	-3	0		-3	0	94%	-1.5	0	97%
+3	0	0	1	0	1.5	2	+3	0	+3	0		+3	1	96%	1.5	2	100%
-4	0	0	1	0	-2	0	-4	0	-4	0		-4	1	97%	-2	0	
+4	0	0	1	0	2	0	+4	0	+4	0		+4	1	99%	2	0	
-5	0	0	0	0	-2.5	0	-5	0	-5	0		-5	0	99%	-2.5	0	
+5	0	0	0	0	2.5	0	+5	0	+5	0		+5	0	99%	2.5	0	
-6	0	0	0	0	-3	0	-6	0	-6	0		-6	0	99%	-3	0	
+6	0	0	0	0	3	0	+6	0	+6	0		+6	0	99%	3	0	
-7	0	0	0	0					-7	0		-7	0	99%		0	
+7	0	0	1	0					+7	0		+7	1	100%		0	
-8	0	0	0	0					-8	0		-8	0			0	
+8	0	0	0	0					+8	0		+8	0			0	
	72	72	72	72		72		72		72			72			72	

The trouser was issued 94% within +/- one size with only 4 trousers out of the acceptable range. Each case is being evaluated for criteria that may have influenced these issues. In most cases the measurement data indicates that the size issued by ARNScan was correct. As the process flow now exists, there are several points at which the information on issue could be incorrect. As mentioned earlier, we cannot document if the item issued out of acceptable range due to an out of stock situation or that the correct information is logged onto the ARNScan issue ticket. We can only verify that the size selected by ARNScan was correct based on the measurement data.

The coat was issued 71% within +/- one size with 21 coats out of the acceptable range. In the majority of these cases, the across shoulder measurement appears to be driving the ARNScan size selection. Upon only preliminary investigation, there appears to have been more variance in this measurement than in the previous two sessions. A list of suspect scans were supplied to Beecher and Cyberware for investigation. The results of length issue have been reviewed. This is not a difficult size selection process. The results indicate the height range needs to be modified by 1 inch. This revision should correct any inaccurate lengths.

The shirt was issued at 89% within the +/- one size with 8 shirts out of the acceptable range. In 6 of these cases, the coat and shirt were issued larger than acceptable

because of across shoulder variations. These were identified in reports to Beecher and Cyberware as cases to evaluate.

Trouser Length Analysis

Trouser length issue is dependent on the stature measurement and inseam length. ARNScan size selection rules determine the range for the stature and then verify that the length will accommodate the inseam required. After review of the data collected during the May ARNScan issue the length rules were modified. After analysis of the length issued by MCRD based on the height it was determined that the upper range of the regular, long, and x-long should be increased. The following table displays a sample of the actual length table used in May and the revised table to be utilized in future size selection scanning sessions.

May Version 5-4 / 5-25 (34 Example)

Waist	Stature		Inseam	
Size	Low	High	Low	High
34 x-short	0	63	0	25
34 short	0	63	25	31
34 short	63	66	25	31
34 regular	63	66	31	33
34 regular	66	69	27	33
34 long	66	69	33	35
34 long	69	72	29	35
34 x-long	69	72	35	37
34 x-long	72	100	31	37
34 Inseam x-long	0	100	0	100

Revision After May Data Analysis

Waist	Stature		Inseam	
Size	Low	High	Low	High
34 x-short	0	63	0	25
34 short	0	63	25	31
34 short	63	66	25	31
34 regular	63	66	31	33
34 regular	66	71	27	33
34 long	66	71	33	35
34 long	71	73	29	35
34 x-long	71	73	35	37
34 x-long	73	100	31	37
34 Inseam x-long	0	100	0	100

The table section, May Issue, illustrates the overlap of length issued by MCRD. This analysis provided the basis for the length size selection rule modifications. As the table indicates, MCRD issued 55 regular and 5 short trousers with the same height range. The most critical area was the long. MCRD issued 28 long and 27 regular trousers with the same height range. The x-long could be improved at 8 x-long and 9 long being issued with the same range. The challenge was to determine how the length ranges could best be modified considering that there was overlap in the actual issuing process.

May Issue			
Height (Stature measurement)	ARN Rule	MCRD Issue	
0-66	Short	Short	25
66-69	Regular	Regular	55
66-69	Regular	Short	5
69-72	Long	Long	28
69-72	Long	Regular	27
72-100	X-long	X-long	8
72-100	X-long	Long	9
Note: No x-short lengths were issued			

May Issue Revised Rules			
Height (Stature measurement)	ARN Rule	MCRD Issue	
0-66	Short	Short	23
0-66	Short	Regular	2
66-71	Regular	Regular	81
66-71	Regular	Short	5
66-71	Regular	Long	10
71-73	Long	Long	23
71-73	Long	Regular	1
73-100	X-long	X-long	9
73-100	X-long	Long	3
Note: No x-short lengths were issued			

The table section, May Issue Revised Rules, illustrates the improvement of length issue based on the revised rules. The largest improvement was in the regular. Using the new stature ranges, the MCRD length issued matched the ARNScan rule 81 times verses only 55 with the past rule version. Other smaller improvements were made in the long and x-long lengths.

The MCRD length issue and the ARNScan issue do not match exactly after rule modification as noted in the following table. After analyzing the data with several rule versions, it was determined that the accepted revised rule set most closely matched MCRD. May resulted in 113 ARN and MCRD issues the same length verses 134 with the revised rules. There are still several cases where recruits with the same height were issued different lengths. This is expected, as the issue process is being determined by visual observation. The rule sets cannot use a math range and issue two different lengths for the same height. Therefore, the rules are more consistent and are expected to provide acceptable size selection.

		May Rules	Revised Rules
ARN & MCRD Same	0	113	134
ARN Issue 1 size shorter than MCRD	-1	3	14
ARN Issue 1 size longer than MCRD	+1	41	9
Total		157	157

Coat Length Rules

Coat length is dependent on the stature measurement in ARNScan size selection rules. After review of the data collected during the May ARNScan issue the rules were modified.

May Version 5-4 / 5-25 Coat

	Stature	
Size	Low	High
x-short	0	64
Short	64	67
Regular	67	70
Long	70	73
x-long	73	100

Revision After May Data Analysis

	Stature	
Size	Low	High
x-short	0	64
short	64	68
regular	68	71
long	71	74
x-long	74	100

The table section, May Issue, demonstrates the overlap of length issued by MCRD. The analysis of this data provided the basis for the length size selection rule modifications. As the table indicates, MCRD issued 33 short and 5 x-short trousers with the same height range. The significant length was the regular. MCRD issued 42 regular and 14 short trouser lengths within the same height range. The challenge, as with the trouser length, is how to best adjust the height range considering the overlap in the actual issuing process.

May Issue				May Issue Revised Rules			
Height (Stature measurement)	ARN Rule	MCRD Issue		Height (Stature measurement)	ARN Rule	MCRD Issue	
0-64	x-short	x-short	5	0-64	x-short	x-short	5
64-67	short	Short	33	64-68	short	short	42
64-67	short	x-short	5	64-68	short	x-short	5
67-70	regular	Regular	42	64-68	short	regular	8
67-70	regular	Short	14	68-71	regular	regular	47
70-73	long	Long	34	68-71	regular	short	6
70-73	long	Short	1	68-71	regular	long	8
70-73	long	Regular	13	71-74	long	long	30
73-100	x-long	x-long	6	71-74	long	x-long	1
73-100	x-long	Long	4	74-100	x-long	x-long	5

The second section of the table, May Issue Revised Rules, shows some improvement of length issued. The most notable changes were short 33 to 42 and regular 42 to 47 issued by the adjusted height range. The process is to find the height range that best relates to the actual length issued by MCRD for a specific height. This will allow ARNScan rules to issue coat lengths in the future with respect to height in the same way they are being issued by visual observation presently. The revised rules best simulate the existing process, taking into consideration the variability.

	MCRD Height Range		
Coat Length	Low	High	Overlap
x-short	62.06	- 65.84	X-short overlap with short 1.81"
Short	64.03	- 70.25	Short overlap with regular 3.15"
Regular	67.10	- 70.96	Regular overlap with long .71"
Long	70.25	- 73.95	Long overlap with x-long .25"
x-long	73.71	- 76.23	

The following examples illustrate the reason for difficulty in generating size selection rules that will match all of the length issues in the data set. The first example is of four recruits indicating height, length issued by MCRD, and length issued by the ARNScan height rules. The recruits all measured 70.25 in height. The ARNScan rule would always issue a regular for this height. The four recruits were issued one short, one long, and two regular coats. The height, 70.25, is near the upper range limit for a regular and therefore, could wear a regular or a long. The measurements alone do not indicate the reason for the short issue. ARNScan rules will always issue the same length based on the height range. The visual observation on a very small percentage may indicate a one size change. In the case where the long was issued, the ARNScan issue of regular would be acceptable. When analyzing the data size selection outcomes, those that indicate a +/- 1 size are considered acceptable in reviewing the capability of the size selection rules.

Scan Number	scan date	Height (stature)	MCRD Length	ARN Revised Rule Issue	Scan Number	scan date	Height (stature)	MCRD Length	ARN Revised Rule Issue
10000259	19990504	70.25	short	Regular	10000404	19990518	67.89	regular	short
10000269	19990504	70.25	long	Regular	10000476	19990525	67.89	short	short
10000382	19990518	70.25	regular	Regular					
10000450	19990525	70.25	regular	Regular	10000261	19990504	68.20	short	regular
					10000393	19990518	68.20	regular	regular
10000383	19990518	65.05	x-short	Short					
10000392	19990518	65.05	short	Short	10000379	19990518	68.44	regular	regular
10000480	19990525	65.05	short	Short	10000507	19990525	68.44	short	regular
10000371	19990518	65.60	short	Short	10000396	19990518	70.33	regular	regular
10000465	19990525	65.60	x-short	Short	10000470	19990525	70.33	long	regular
10000474	19990525	65.60	short	Short					
					10000501	19990525	70.41	long	regular
10000403	19990518	65.76	x-short	Short	10000515	19990525	70.41	regular	regular
10000444	19990525	65.76	short	Short					
					10000233	19990504	70.96	regular	regular
10000236	19990504	65.84	x-short	Short	10000498	19990525	70.96	long	regular
10000397	19990518	65.84	short	Short					
					10000251	19990504	67.81	short	short
10000448	19990525	67.49	short	Short	10000493	19990525	67.81	regular	short
10000459	19990525	67.57	regular	Short					
					10000264	19990504	67.73	short	short
					10000369	19990518	67.73	regular	short

The following table compares the May length rule issues to the revised length rules. The cases of the ARNScan size selection rules issuing the same as MCRD increased from 120 to 129. The other notable change was the centering of the other cases around zero where they were skewed in the positive direction previously. This would lead the researcher to assume the revised rule set is closest to imitating the manual process with several cases that two lengths were acceptable as mentioned earlier.

Coat		May Rules	Revised Rules
ARN & MCRD Same	0	120	129
ARN Issue 1 size shorter than MCRD	-1	0	17
ARN Issue 1 size longer than MCRD	+1	36	11
ARN Issue 2 size longer than MCRD	+2	1	
Total		157	157

The following table shows a summary of the May issue analysis described in this report.

Summary May ARNScan Size Selection

Summary May ARNScan Size Selection										May 4, 1999 ARNScan Issue										May 18, 1999 ARNScan Issue										May 25, 1999 ARNScan Issue									

Summary as a Accumulative Percent

TROUSER SIZE

4-May					18-May					25-May				
0	22	54%	38	52%	23	52%	38	53%		38	52%	38	53%	
-1	5	66%	12	61%	4	61%	12	69%		12	61%	12	69%	
+1	8	85%	18	93%	14	93%	18	94%		18	93%	18	94%	
-2	1	88%	2	93%	0	93%	2	97%		2	93%	2	97%	
+2	2	93%	2	100%	3	100%	2	100%		2	100%	2	100%	
-3	0	93%	0		0		0			0		0		
+3	1	95%	0		0		0			0		0		
-4	0	95%	0		0		0			0		0		
+4	0	95%	0		0		0			0		0		
-5	0	95%	0		0		0			0		0		
+5	1	96%	0		0		0			0		0		
-6	0	96%	0		0		0			0		0		
+6	0	96%	0		0		0			0		0		
-7	0	96%	0		0		0			0		0		
+7	0	96%	0		0		0			0		0		
-8	0	96%	0		0		0			0		0		
+8	1	100%	0		0		0			0		0		
Total	41		41		44		44			72		72		

COAT SIZE

4-May					18-May					25-May				
0	13	32%	19	43%	19	43%	14	19%		14	43%	14	19%	
-1	12	61%	4	52%	4	52%	25	54%		25	52%	25	54%	
+1	5	73%	15	86%	15	86%	12	71%		12	86%	12	71%	
-2	0	73%	3	93%	3	93%	5	88%		5	93%	5	88%	
+2	3	80%	1	95%	1	95%	0	94%		0	95%	0	94%	
-3	0	80%	1	98%	1	98%	0	94%		0	98%	0	94%	
+3	4	90%	1	100%	1	100%	1	96%		1	100%	1	96%	
-4	0	90%	0		0		1	97%		1		0	97%	
+4	2	95%	0		0		1	99%		1		0	99%	
-5	0	95%	0		0		0	99%		0		0	99%	
+5	0	95%	0		0		0	99%		0		0	99%	
-6	0	95%	0		0		0	99%		0		0	99%	
+6	2	100%	0		0		0	99%		0		0	99%	
-7	0		0		0		1	100%		1		0	100%	
+7	0		0		0		0			0		0		
-8	0		0		0		0			0		0		
+8	0		0		0		0			0		0		
Total	41		44		44		72			72		72		

SHIRT SIZE

4-May					18-May					25-May				
0	25	61%	29	66%	29	61%	34	47%		34	66%	34	47%	
-0.5	2	66%	1	68%	1	66%	6	56%		6	68%	6	56%	
0.5	12	95%	9	89%	9	95%	24	89%		24	89%	24	89%	
-1	0	95%	0	89%	0	95%	0	89%		0	89%	0	89%	
+1	1	98%	5	100%	5	98%	6	97%		6	100%	6	97%	
-1.5	1	100%	0		0	100%	2	100%		2		2	100%	
1.5	1		0		0		0			0		0		
-2	0		0		0		0			0		0		
+2	0		0		0		0			0		0		
-2.5	0		0		0		0			0		0		
2.5	0		0		0		0			0		0		
-3	0		0		0		0			0		0		
3	0		0		0		0			0		0		
Total	41		44		44		72			72		72		

8.2 ARNScan Session at MCRD San Diego May, 1999 (Modifications)

May Size Selection With Software Modifications

Scan and size selection data collected at MCRD, San Diego in May 1999 is summarized in the following tables. Also a section has been added for a size selection run processed in July 1999. The July data results were generated using the recruit scans collected in May 1999. The scans were processed with modified ARNScan software for measurement extraction. A new tool was being tested for across shoulder and sleeve length and a different tool for waist.

May Analysis and July Analysis Coat ARNScan Issue									May Analysis and July Analysis Trouser ARNScan Issue										
	May		July		Accumulative Percentage					May		July		Accumulative Percentage					
	Size		Size			May		July			Size		Size			May		July	
0	48		53		0	48	30%	53	34%	0	83		77		0	83	53%	77	49%
-1	40		34		-1	40	56%	34	56%	-1	21		17		-1	21	66%	17	60%
+1	32		34		+1	32	76%	34	78%	+1	40		50		+1	40	92%	50	92%
-2	19		23		-2	19	88%	23	92%	-2	3		3		-2	3	94%	3	94%
+2	8		3		+2	8	93%	3	94%	+2	7		6		+2	7	96%	6	96%
-3	1		5		-3	1	94%	5	97%	-3	0		0		-3	0	96%	0	98%
+3	3		2		+3	3	96%	2	99%	+3	1		1		+3	1	99%	1	99%
-4	1		0		-4	1	96%	0	99%	-4	0		0		-4	0	99%	0	99%
+4	4		2		+4	4	99%	2	100%	+4	0		0		+4	0	99%	0	99%
-5	0		0		-5	0	99%	0		-5	0		0		-5	0	99%	0	99%
+5	1		0		+5	1	99%	0		+5	1		1		+5	1	99%	1	99%
-6	0		0		-6	0	99%	0		-6	0		0		-6	0	99%	0	99%
+6	0		0		+6	0	99%	0		+6	0		0		+6	0	99%	0	99%
-7	0		0		-7	0	99%	0		-7	0		0		-7	0	99%	0	99%
+7	1		0		+7	1	100%	0		+7	0		0		+7	0	99%	0	99%
-8	0		0		-8	0		0		-8	0		0		-8	0	99%	0	99%
+8	0		0		+8	0		0		+8	1		1		+8	1	100%	1	100%
Total	157		156			158		156			157		156			157		156	

As in the previous analysis, the ARNScan size issued was compared to the MCRD size issued. The determination of success is defined in the following manner: same size as MCRD (0), one size larger (+1), one size smaller (-1), etc. The summary table lists the comparison of the May scan session issue to MCRD and also the comparison of those same scans processed through size selection with modified ARNScan software.

The ARNScan software used in the July size selection run included a modified across shoulder tool. The graphical analysis of the previous ARNScan V.9.0 and the new modified tool is detailed in the Beecher/Ring repeatability preliminary report included in ST030799IPR and also posted on the ARN web page in the final summary report.

As the table indicates the modification of the across shoulder tool did not result in significant improvement of coat size selection. The May accumulative issue through +/- 1 size was 76% and the July accumulative issue was 78%.

The only measurement that impacted the July run of trouser size selection was the change from the Waist-Geometry tool to the Waist-Predict. The summary data indicates no change in the size selection based on +/-1 size. The accumulative in May was 92% with the July run remain the same at 92%.

May Analysis and July Analysis Shirt ARNScan Issue								May to July Shirt Sleeve ARNScan Issue							
				Accumulative Percentage								Accumulative Percentage			
May Size		July Size		May		July		May Sleeve		July Sleeve		May Sleeve		July Sleeve	
0	92	94		0	92	59%	94	60%	0	71	66	0	71	45%	66
-0.5	9	23		-0.5	9	64%	23	75%	-1	50	22	-1	50	77%	22
0.5	41	30		0.5	41	90%	30	94%	+1	27	56	+1	27	94%	56
-1	0	0		-1	0	90%	0	94%	-2	8	2	-2	8	99%	2
1	13	8		1	13	99%	8	99%	+2	1	10	+2	1	100%	10
-1.5	0	0		-1.5	0	99%	0	99%							
1.5	2	1		1.5	2	100%	1	100%							
-2	0	0		-2	0		0								
2	0	0		2	0		0								
-2.5	0	0		-2.5	0		0								
2.5	0	0		2.5	0		0								
-3	0	0		-3	0		0								
3	0	0		3	0		0								
					0		0								
					0		0								
					0		0								
					0		0								
	157	156			157		156			157	156		157		156

The ARNScan software used in the July size selection run included a modified across shoulder and a new sleeve length tool, which could have impacted the shirt size issued. The graphical analysis of the new tool results is detailed in the Beecher/Ring Repeatability Summary Report to be posted to the ARN home page.

As the table indicates the modification of the across shoulder tool resulted in a small improvement of the shirt size selection. The May accumulative shirt issue through +/-1/2 neck size was 90% with an improvement to 94% for the July run.

The sleeve length issue actually resulted in a decline from May of 94% to July 92%. The graphical analysis by Beecher indicates that the new tool is much more consistent. Other factors affecting the sleeve length issue including the across shoulder measurement and the algorithm for adjusting the measurement from the wrist locator to the appropriate point on the hand between the thumb joint and the wrist. Thus far, the analysis indicates that the new approach is an improvement but all variables need further adjustment to obtain the best results in size selection.

8.3 ARNScan Session at MCRD November, 1999

The November scan data report was received from Cyberware. The scanner had been previously taken off base for a presentation requested by Program Management and was reinstalled at MCRD just prior to this scanning period. The process of scanning and collecting data were being performed as Cyberware trained MCRD staff to run the scanner. Garments were not being issued from the ARNScan issue printout but by the fitter in the present process. The size issued by MCRD was documented and provided to Cyberware staff for use in size analysis.

Recruit data was sorted and analyzed based on the ARNScan size issue verses MCRD size issue. Much additional variability was introduced into the scanning process with the reinstallation of the scanner, training of new staff to pose the recruit and run the scanner, and data collection that may have been reported inaccurately due to time constraints and the many activities being performed during the fitting procedure. Each measurement set that was not within +/- 1 was reviewed and comments documented for Cyberware staff to evaluate. The summary was as follows:

November Data Analysis: Service Coat

Total of Range -2 > -5 =	156	Total of Range +2 > +8	28
Total scans	440	Total scans	440
Percent of total	36%	Percent of total	6%

Approximately half of the 156 scans that were issued by ARNScan over one size smaller than MCRD indicated a smaller shoulder than expected. The posturing of the recruit during scanning can affect the across shoulder measurement and would be expected during a training session. The other half did not have any measurement that indicated that the ARNScan size was incorrect. In most cases the measurement data indicated that the size issued by MCRD was larger than expected.

The scans that were issued more than one size larger by ARNScan were evaluated for unexpected measurements. Several were determined bad scans and should not be included in further analysis. The balance was a very small percentage of the total scans evaluated and was acceptable.

The results of the data analysis for the Service Coat are detailed in the following table. The Accumulative percentage by range was compared to the statistics from the May 1999 data collection. The comparison indicated, as expected, that the November issue was not as close to MCRD as the May issue. The May data was collected after other scanning sessions with the scanner installed at MCRD and also the garments were issued using the ARNScan size selection rather than by the fitter the first time.

November 1999 Scan Data Analysis: Service Coat

Range ARN-MCRD %	Accumulative Size Issue %	Range ARN – MCRD	SIZE	LENGTH	Accumulative Length %
0.22	0.22	0	98	329	0.75
0.30	0.53	-1	133	50	0.86
0.06	0.58	+1	25	59	1.00
0.25	0.84	-2	112	0	
0.02	0.85	+2	8	0	
0.08	0.94	-3	36	0	
0.02	0.96	+3	10	2	
0.02	0.98	-4	7	0	
0.01	0.98	+4	4	0	
0.00	0.99	-5	1	0	
0.00	0.99	+5	1	0	
0.00	0.99	-6	0	0	
0.00	0.99	+6	2	0	
0.00	0.99	-7	0	0	
0.00	1.00	+7	1	0	
0.00	1.00	-8	0	0	
0.00	1.00	+8	2	0	
		Total	440	440	

Comparison of Accumulative % Hits May Data to Nov Data: Service Coat

May Accu %	Nov Accu %	ARN – MCRD	May Data	Nov Data
34	22	0	53	98
56	53	-1	34	133
78	58	+1	34	25
92	84	-2	23	112
94	85	+2	3	8
97	94	-3	5	36
99	96	+3	2	10
99	98	-4	0	7
100	98	+4	2	4
			Total 156	Total 433

The November data was analyzed in a similar manner for the shirt issue. The results are detailed in the following tables. Each measurement set that was not within +/- .5 (one size) was reviewed and comments documented for Cyberware staff to evaluate. The summary was as follows:

November Data Analysis: Long Sleeve Shirt

Total of Range $-1 > -1.5$ =	18	Total of Range $+1 > +2$	13
Total scans (issue data)	361	Total scans	361
Percent of total	5%	Percent of total	4%

The shirt issues in the group where ARNScan issued more than one size smaller than MCRD were examined. These outcomes were also compared to the coat issue for the same recruit. In 17 of the 18 cases the small shoulder or chest was supported by the coat issue. The coat was also issued smaller than MCRD due to these suspect measurements. In the remaining case there was no coat issue data available. Based on this analysis, the shirt rules appear to be issuing appropriately based on the measurement data available.

The shirt issues in the group where ARNScan issued more than one size larger than MCRD were examined. These outcomes were compared to the coat issue for the same recruit. In 5 cases the coat was issued large based on a large across shoulder measurement also, supporting the assumption that the across shoulder measurement should be reviewed.

In 6 cases the measurements indicated that the ARN issue was a better fit than the MCRD issue size. In these cases the MCRD garment allowed no ease in the shoulder. This again indicates that the across shoulder was perhaps running larger than the actual measurement. Generally MCRD would not issue a garment this small if the shoulder measurement were accurate. In 2 cases the size issue difference would have only been .5 except for a small increment in the measurement data. For example, a measurement being .03 higher than a rule range for that measurement caused the size to roll up one.

The first measurement to be critical in the shirt is the neck. Therefore, the impact that a small or large across shoulder measurement has is less than on the coat where the most critical measurement is the across shoulder. This is demonstrated by the large percentage of negative issues on the coat (36%) as compared to the shirt (5%). It appears that the shirt rules are selecting acceptable sizes based on the ARNScan measurement data.

November 1999 Scan Data Analysis: Long Sleeve Shirt

Range ARN-MCRD %	Accumulative Size Issue %	Range ARN – MCRD	Neck Size	Sleeve Length	Accumulative Length %
0.43	0.43	0	156	75	0.23
0.22	0.65	-0.5	78		
0.27	0.91	+0.5	96		
0.04	0.96	-1	16	125	0.61
0.03	0.99	+1	10	9	0.64
0.01	0.99	-1.5	2		
0.01	1.00	+1.5	2		
0.00	1.00	-2	0	89	0.91
0.00	1.00	+2	1	0	0.91
0.00	1.00	-2.5	0		
0.00	1.00	+2.5	0		
0.00	1.00	-3	0	24	0.99
0.00	1.00	+3	0	0	0.99
0.00	1.00	-3.5	0		
0.00	1.00	+3.5	0		
0.00	1.00	-4	0	3	1.00
0.00	1.00	+4	0	0	1.00
0.00	1.00	-4.5	0		
0.00	1.00	+4.5	0		
0.00	1.00	-5	0	1	1.00
0.00	1.00	+5	0	0	1.00
		Total	361	326	

Comparison of Accumulative % Hits May Data to Nov Data: Shirt

May Accu %	Nov Accu %	ARN – MCRD	May Data	Nov Data
60	43	0	94	156
75	65	-0.5	23	78
94	91	+0.5	30	96
94	96	-1	0	16
99	99	+1	8	10
99	99	-1.5	0	2
100	100	+1.5	1	2
		-2	0	0
		+2	0	1
			Total 156	Total 361

The November data was analyzed in a similar manner for the trouser issue. The results are detailed in the following table. Each measurement set that was not within +/- 1 was reviewed and comments documented for Cyberware staff to evaluate. The summary was as follows:

November Data Analysis: Trouser

Total of Range -2 > -8 = 56	Total of Range +2 > +8 12
Total scans (issue data) 440	Total scans 440
Percent of total 12%	Percent of total 3%

The trouser issues in the group where ARNScan issued more than one size smaller than MCRD were examined. The 5 issues larger than +2 were identified to have unacceptable seat measurements. This was also verified by the large issue on the coat by ARN verses the MCRD issue.

The 7 issues more than 2 sizes smaller than MCRD were also examined. It was determined that on the three most extreme cases (-8>-10) the issue by ARN better met the fit needs of the measurement data set than the MCRD. The issue by MCRD was so far from the fit standard that we can presume that the data entry for the size issued was incorrect. In the three issues of -3, it was determined that based on the measurement data set the ARNScan issue was closer to standard fit.

Comparison of Accumulative % Hits May Data to Nov Data: Trouser

May Accu %	Nov Accu %	ARN - MCRD	May Data	Nov Data
.49	.36	0	77	158
.60	.73	-1	17	164
.92	.85	+1	50	50
.94	.96	-2	3	50
.98	.98	+2	6	8
.98	.99	-3	0	4
.99	.99	+3	1	2
.99	.99	-4	0	0
		+4	0	0
		-5	0	0
		+5	1	1
		-6	0	0
		+6	0	0
		-7	0	0
		+7	0	0
		-8	0	2
		+8	1	1
			Total 156	Total 440

As noted earlier, this data was collected during a period of time that allowed for excessive variability.

8.4 ARNScan Session with WBX Scanner at MCRD February, 2000

The ARNScan scanner was removed from MCRD and a newer version known as the Cyberware WBX Whole Body scanner was delivered, installed, and put into operation in late January, 2000. Approximately 156 scans were collected at MCRD February 1 – 2, 2000 with the more recent version of the whole body scanner. This model was developed for use in the military environment. Additional information on the development and implementation of the new scanner can be found in the Cyberware reports.

The scan data was received in the standard report format at SPSU for review. Ring analyzed the general distribution of the data but specifically a list of recruits specified by Cyberware. Communication with Cyberware programming staff took place throughout the month, as more information was determined on the list of specific scans. The report containing this information was sent to Cyberware staff for further review.

February 2000 Scan Data Review

Approximately 600 scans were collected at MCRD with the WBX scanner February 1 – 16, 2000. The ARNScan Size Issue Reports were provided with three different across shoulder adjustments to compare; outcomes with no adjustment, an overall adjustment, and an adjustment that only impacted extremely large shoulders. It was determined in the preliminary analysis that the outcomes with only specific size shoulders adjusted gave the best results. The algorithm will be referred to as x-shoulder. Ring analyzed the general distribution of the data but specifically a list of 90 recruits that had larger than normal across shoulder measurements. Communication with Cyberware programming staff took place throughout the month as more information was determined on the list of specific scans. The report containing this information was sent to Cyberware staff for further review.

The preliminary analysis included evaluating the range of across shoulders that were included within the 90 scans that were determined to have been adjusted by the x-shoulder function. The following table details the comparison of ARN size issue to MCRD. A negative outcome of the size comparison indicates that ARN issued a size smaller than MCRD, therefore, a positive outcome indicates that ARN issued a larger size than MCRD and zero indicates the same size issued. The analysis does not indicate that the range of shoulders within any size comparison outcome was significantly different than the others. The count indicates a normal distribution and therefore does not lead the analyst to any specific conclusion.

X-Shoulder Function Comparison on Coat

Size Issue Comparison	Min Shoulder	Max Shoulder	Count
-5 thru -3	19.25	20.39	3
1—2	19.25	20.87	10
-1	19.25	20.28	17
0	19.25	21.61	28
+1	19.29	20.83	18
+2	19.84	21.14	8
+4 thru +5	19.33	20.39	2

Test Data Analysis Men Coat

The x-shoulder function adjusts shoulders larger than a predetermined set value based on that value only. A new Test algorithm was developed at SPSU for the across shoulder measurement. This function compares the across shoulder measurement to the chest and determines if the measurement is out of a specific range based on what is expected for that specific scan chest measurement. If the across shoulder measurement is larger than the allowed range it is adjusted accordingly. Taking into consideration the limited number of measurements extracted and the time constraints, the chest was used for this analysis as the baseline measurement for adjustment of suspect across shoulder measurements extracted. Several across shoulder ranges were used to test the outcomes. Only the Test Data currently being analyzed is included in this report. There remained a total of 550 subjects in the February data sets, after removing subjects that did not have complete issue data.

The February data analysis included ARNScan Issue verses MCRD Issue using the ARNScan across shoulder measurement with no adjustment, size issue with the x-shoulder adjustment, and size issue with the Test Data adjustment. Size selection outcomes were compared in the process of determining the across shoulder measurement that resulted closer to the actual MCRD issue size. These results are listed in the following table.

Comparison of Coat ARNScan across Shoulder, X-Shoulder, SPSU Test Data

ARN Size Minus MCRD Size				Accumulative Count			Accumulative Percentage		
ARN-MCRD	ARNScan Across Shoulder	X-Across Shoulder	Test Data Across Shoulder	ARNScan Across Shoulder	X-Across Shoulder	Test Data Across Shoulder	ARNScan Across Shoulder	X-Across Shoulder	Test Data Across Shoulder
0	262	278	295	262	278	295	.48	.51	.54
-1	47	64	92	309	342	387	.56	.63	.71
+1	75	93	75	384	435	462	.70	.80	.84
-2	15	24	38	399	459	500	.73	.84	.91
+2	58	48	25	457	507	525	.84	.93	.96
-3	3	8	9	460	515	534	.84	.94	.98
+3	27	20	8	487	535	542	.89	.98	.99
-4	0	2	3	487	537	545	.89	.98	1.00
+4	22	4	2	509	541	547	.93	.99	
-5	0	1	0	509	542		.93	.99	
+5	19	5	0	528	547		.97	1.00	
>5	19	0	0	19 > 5					

As the data table indicates, the largest number of subjects issued the same size by ARNScan and MCRD was Test Data. ARNScan 262, X-shoulder 278 and Test Data 295 results in an improvement of 17 exact hits by Test Data over x-shoulder. The across shoulder percentage of total was ARNScan 48%, X-shoulder 51%, and Test Data 54%. The accumulative count through +2 comparison was ARNScan 457, X-shoulder 507, and Test Data 525. The table indicates that an adjustment is definitely needed on the across shoulder. How this adjustment is structured is the factor to be determined. Researchers at Cyberware and Southern Poly have been aware of this issue and have progressively addressed it throughout the project life. How complex the adjustment could be has changed as the software has developed during this time period.

One of the most complex measurement issues has been extremely large across shoulder measurements on specific subjects. Much analysis was performed by Beecher and other partners in the past research with no final determination of why some subjects across shoulder measurement is extremely larger than the expected value. It has been determined that it is a combination of possibilities: the posture of the subject, the posing of the subject, the body build and so on. Comparing the raw measurement to the chest for verification seems to be the best adjustment with the present level of measurement extraction software and the scan pose limited to one.

The range of shoulder measurements, minimum and maximum, for each chest increment included in the tariff for the coat was determined for the anthropometric data, ARNScan data with no adjustment, X-shoulder, and Test Data. The following table lists this data for comparison.

Across Shoulder Measurements verses Chest Minimum/Maximum Range

TData – ARN No Adj Count	ANTRO COUNT	CHEST	Across Shoulder Spec	ANTRO Min	ANTRO Max	ARNSCAN Min	ARNSCAN Max	X- Shoulder Min	X- Shoulder Max	Test Data Min	Test Data Max
1	0	29	14.50			17.28	17.28	17.28	17.28	17.28	17.28
0	0	30	14.75								
2	0	31	15.00			16.93	18.23	16.93	18.23	16.93	17.35
7	0	32	15.25			14.37	17.64	14.37	17.64	14.37	17.35
4	2	33	15.50	16.10	16.42	15.47	17.24	15.47	17.24	15.47	17.10
15	9	34	15.75	14.80	17.17	14.06	18.35	14.06	18.35	14.06	16.85
37	14	35	16.00	15.16	17.72	15.63	19.76	15.63	18.66	15.63	17.10
52	19	36	16.25	15.71	18.27	15.08	19.45	15.08	19.02	15.08	17.35
68	33	37	16.50	14.69	18.74	15.98	20	15.98	19.13	15.98	17.87
69	37	38	16.75	15.79	18.90	14.29	20.71	14.29	19.17	14.29	17.85
78	26	39	17.00	15.55	18.31	15.24	20.08	15.24	19.21	15.24	18.10
89	30	40	17.25	15.79	19.29	15.79	20.83	15.79	19.21	15.79	18.35
55	13	41	17.50	14.21	18.90	15.31	20.98	15.31	19.17	15.31	18.60
54	10	42	17.75	16.02	18.50	16.61	20.39	16.61	19.17	16.61	18.85
25	5	43	18.00	15.63	18.35	17.01	20.94	17.01	19.17	17.01	19.10
16	3	44	18.25	17.13	18.54	17.24	21.22	17.24	19.29	17.24	19.35
7	0	45	18.50			17.91	21.61	17.91	19.65	17.91	19.60
3	0	46	18.75			18.94	20.63	18.78	19.13	18.94	19.85

The anthropometric data was used as one guideline in setting the across shoulder maximum range for the across shoulder. The sample data of only 200 is not large enough to be the only baseline but was taken into consideration. Across shoulder test parameters will continue to be evaluated. The following charts display the minimum and maximum of each across shoulder being evaluated verses the measurement specification. Comparing the spikes of the across shoulder range for each across shoulder input (Anthro, ARNScan, X-Shoulder, Test Data) indicates that the Test Data better approximates the anthropometric and the specification target for each chest size. This is proven by the outcomes discussed previously in this report.

The following chart indicates the decision that the software would make based on the ARNScan across shoulder measurement test data algorithm.

The algorithm flows as follows:

- ◆ ARNScan chest measurement range is found
- ◆ ARNScan across shoulder measurement is compared to the maximum allowed
- ◆ If the measurement is smaller than the high end of the range the shoulder measurement to be used for size selection is equal to ARNScan
- ◆ If the measurement is larger than the low end of the high range the measurement is adjusted to the maximum across shoulder

The improvement using the Test Data (previous algorithm) based on a comparison of the across shoulder measurement to the chest measurement is significant, as noted in the comparison tables. As scan data measurements are provided by Cyberware, a larger sample will be tested for additional adjustments in the across shoulder algorithm.

Algorithm Rules for Across Shoulder Adjustment Resulting in Test Data Outcomes

Algorithm for Across Shoulder

Chest Chest Across shoulder Should

Chest	Low	High	Low	High	Equals	Spec	Max
30	0	30.49	0.00	17.35	ADJ Shl		Across Shld
30	0	30.49	17.35	100	17.35	14.75	17.35
31	30.5	31.49	0	17.35	ADJ Shl		
31	30.5	31.49	17.35	100	17.35	15.00	17.35
32	31.5	32.49	0.00	17.35	ADJ Shl		
32	31.5	32.49	17.35	100	17.35	15.25	17.35
33	32.5	33.49	0.00	17.10	ADJ Shl		
33	32.5	33.49	17.10	100	17.10	15.50	17.10
34	33.5	34.49	0.00	16.85	ADJ Shl		
34	33.5	34.49	16.85	100	16.85	15.75	16.85
35	34.5	35.49	0.00	17.10	ADJ Shl		
35	34.5	35.49	17.10	100	17.10	16.00	17.10
36	35.5	36.49	0.00	17.35	ADJ Shl		
36	35.5	36.49	17.35	100	17.35	16.25	17.35
37	36.5	37.49	0.00	17.60	ADJ Shl		
37	36.5	37.49	17.60	100	17.60	16.50	17.60
38	37.5	38.49	0.00	17.85	ADJ Shl		
38	37.5	38.49	17.85	100	17.85	16.75	17.85
39	38.5	39.49	0.00	18.10	ADJ Shl		
39	38.5	39.49	18.10	100	18.10	17.00	18.10
40	39.5	40.49	0.00	18.35	ADJ Shl		
40	39.5	40.49	18.35	100	18.35	17.25	18.35
41	40.5	41.49	0.00	18.60	ADJ Shl		
41	40.5	41.49	18.60	100	18.60	17.50	18.60
42	41.5	42.49	0.00	18.85	ADJ Shl		
42	41.5	42.49	18.85	100	18.85	17.75	18.85
43	42.5	43.49	0.00	19.10	ADJ Shl		
43	42.5	43.49	19.10	100	19.10	18.00	19.10
44	43.5	44.49	0.00	19.35	ADJ Shl		
44	43.5	44.49	19.35	100	19.35	18.25	19.35
45	44.5	45.49	0.00	19.60	ADJ Shl		
45	44.5	45.49	19.60	100	19.60	18.50	19.60
46	45.5	46.49	0.00	19.85	ADJ Shl		
46	45.5	46.49	19.85	100	19.85	18.75	19.85
47	46.5	47.49	0.00	20.10	ADJ Shl		
47	46.5	47.49	20.10	100	20.10	19.00	20.10
48	47.5	48.49	0.00	20.35	ADJ Shl		
48	47.5	48.49	20.35	100	20.35	19.25	20.35

The February data analysis included ARNScan Issue verses MCRD Issue using the ARNScan across shoulder measurement with no adjustment, size issue with the x-shoulder adjustment, and size issue with the Test Data adjustment. Size selection outcomes were compared in the process of determining the across shoulder measurement that resulted closer to the actual MCRD issue size.

Test Data Analysis Men Long Sleeve Shirt

The across shoulder and chest measurement are predictors of the long sleeve shirt as well as the men's coat. Any across shoulder adjustments must also provide good results with the shirt size issue. Therefore, a preliminary analysis of the impact of the new adjustment was generated on the shirt. A printout of the rule tables and the measurements required for shirt size issue including the test across shoulder data were utilized in manually determining the changes in size issue using the test across shoulder. The results are outlined in the following table.

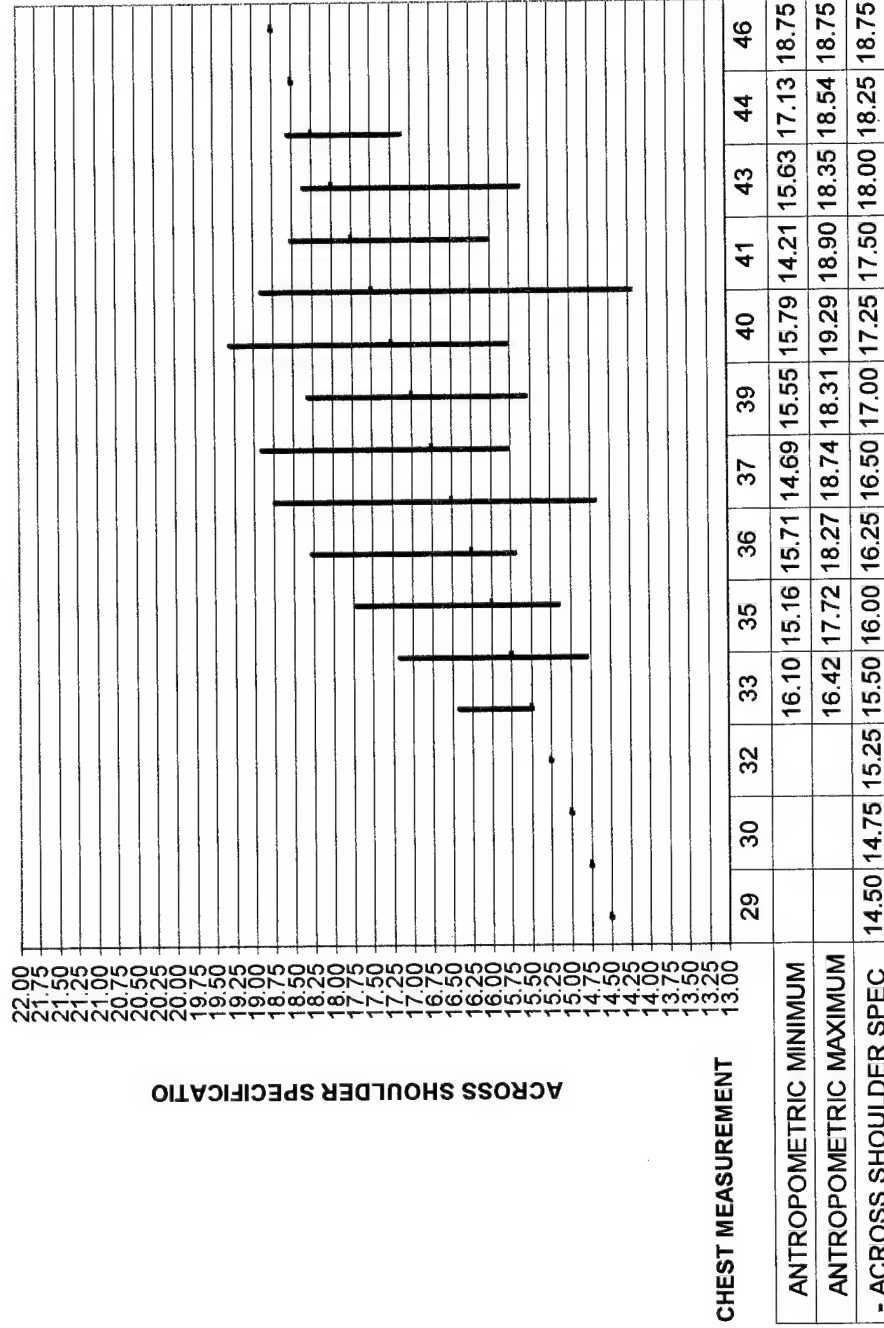
Results of Shirt Issue Analysis

	Accumulative %	X-Shoulder ARN-MCRD	Test Data ARN- MCRD	Accumulative %
0	70	387	367	67
-.5	81	58	74	80
+.5	93	64	68	93
-1	96	20	20	96
+1	99	15	14	99
-1.5		2	3	
+1.5		1	1	
-2		2	2	
		549	549	

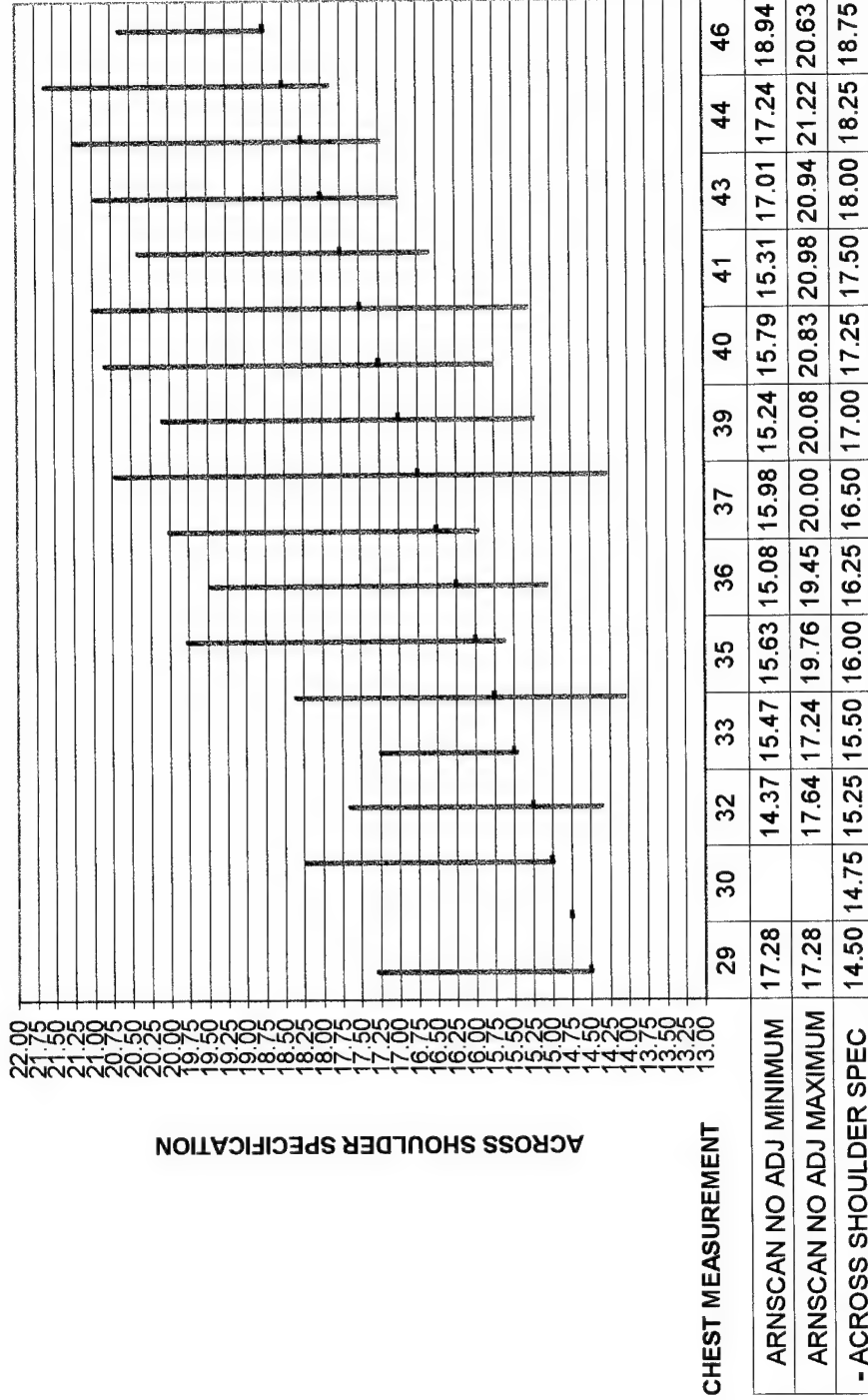
The test data across shoulder adjustment resulted in 20 issues changing from 0, same as MCRD, to one size smaller. This would be expected when the adjustment decreased the across shoulder measurement. These results are assuming no changes to the shirt size issue rule table. It is expected that a small adjustment in the table will be required to bring the size issuing back to the initial results.

This analysis was performed with only 550 test data sets. This was the most efficient way to test different adjustments with size selection manually with the rule table. Current analysis is being performed with all available data from February and March. These results will determine the best performing across shoulder adjustments and only then will the rule tables be reviewed for final modifications.

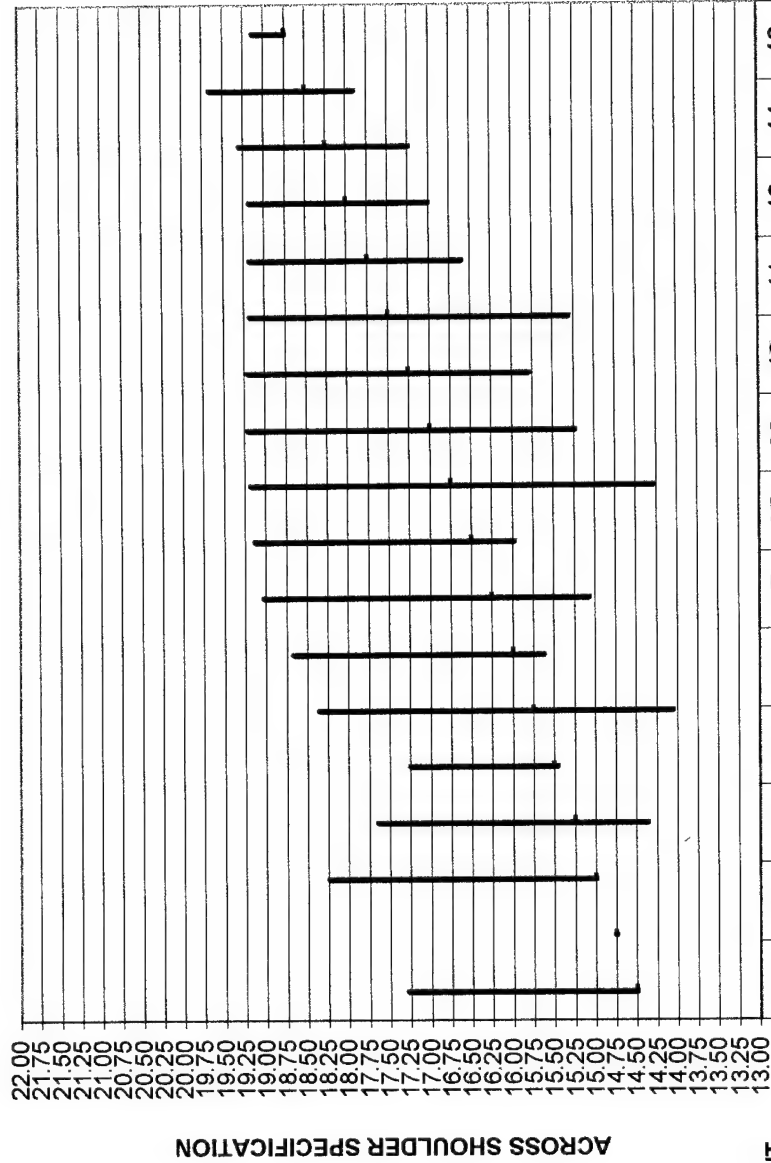
ANTRO DATA ACROSS SHOULDER RANGE VS SPECIFICATION



ARNSCAN DATA ACROSS SHOULDER RANGE VS SPECIFICATION



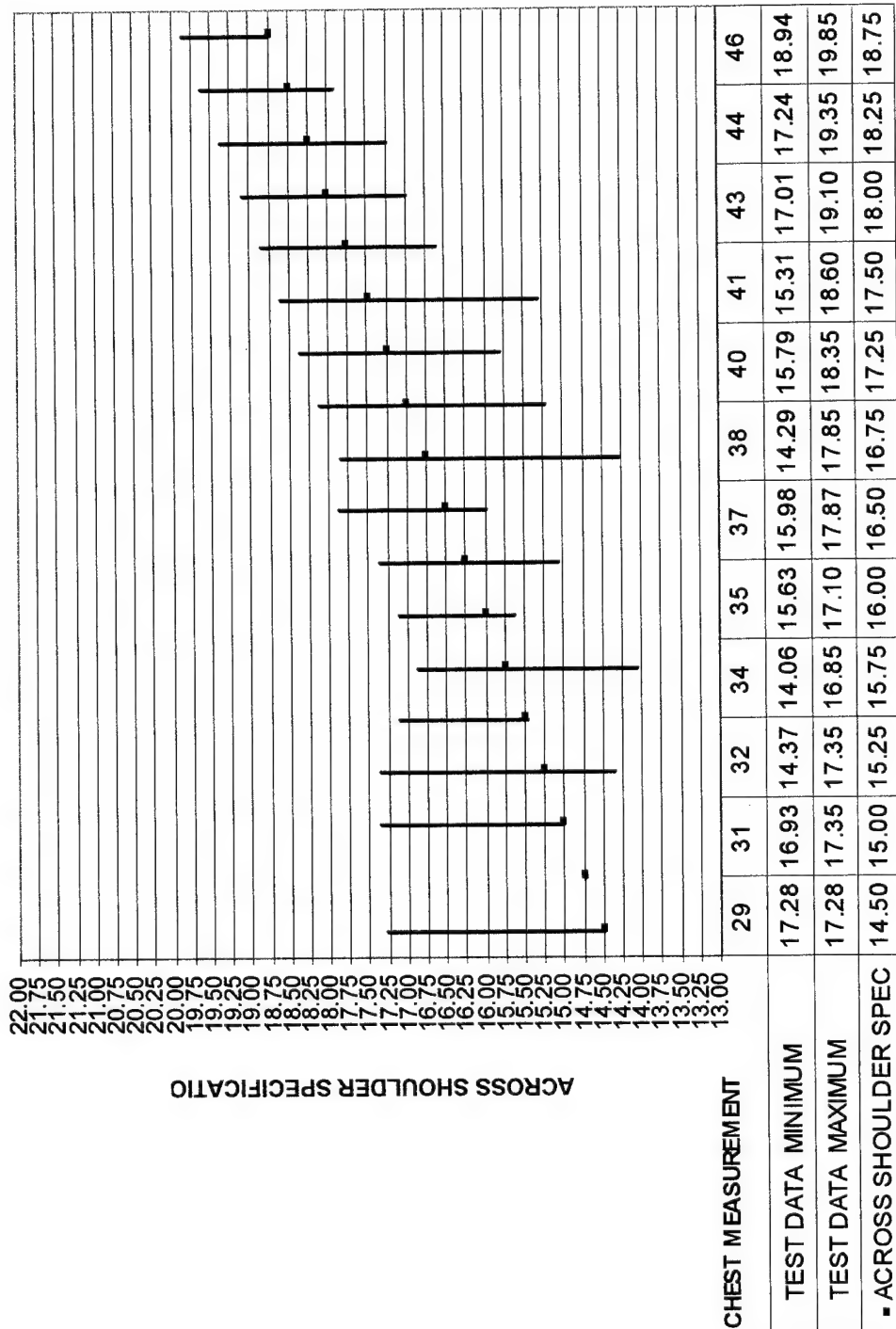
X- ACROSS SHOULDER RANGE VS SPECIFICATION



CHEST MEASUREMENT

X-SHOULDER MINIMUM	17.28	14.37	15.47	15.63	15.08	15.98	15.24	15.79	15.31	17.01	17.24	18.78
X-SHOULDER MAXIMUM	17.28	17.64	17.24	18.66	19.02	19.13	19.21	19.21	19.17	19.17	19.29	19.13
- ACROSS SHOULDER SPEC	14.50	14.75	15.25	15.50	16.00	16.25	16.50	17.00	17.25	17.50	18.00	18.75

TEST DATA ACROSS SHOULDER RANGE VS SPECIFICATION



8.5 ARNScan Session with WBX Scanner at MCRD February - March, 2000

The ARNScan data collected at MCRD February and March 2000 was received in the standard report format at SPSU for review. The ARNScan Size Issue Reports for March were added to the previous database generated for review. The database used during the month of May has approximately 1250 measurement data sets with complete MCRD size issue data as well as ARNScan size issue with X-shoulder adjustment function.

The X-shoulder function adjusts shoulders larger than a predetermined set value based on that value only. A new test algorithm was developed at SPSU for the across shoulder measurement during the investigation of February data. This function compares the across shoulder measurement to the chest and determines if the measurement is out of a specific range based on what is expected for that specific scan chest measurement. If the across shoulder measurement is larger than the allowed range it is adjusted accordingly. Taking into consideration the limited number of measurements extracted and the time constraints, the chest was used for this analysis as the baseline measurement for adjustment of suspect across shoulder measurements extracted.

Several across shoulder ranges were used as the size selection criteria for each measurement set. The across shoulder maximum for each chest range that improved that group of results the most as compared to MCRD was selected to become part of the adjustment algorithm.

Test Data Analysis Men Coat

The February and March data analysis included ARNScan Issue verses MCRD Issue using the ARNScan size issue with the X-shoulder adjustment and size issue with the Test Data adjustment. Size selection outcomes were compared in the process of determining the across shoulder measurement that resulted closer to the actual MCRD issue size. As the previous reports detail, the coat issue using February data showed improvement using the new algorithm for across shoulder. The summary of the accumulative data sets continued to result in an improved issue as compared to MCRD with the additional 600 scans from March. This indicated to the researchers that the introduction of this type of across shoulder adjustment/error checking algorithm would be an improvement to the ARNScan software presently in use. Even though at present the software is not being modified, the concept of this investigation will be valid when software development resumes.

February and March Data Review Results

The results of the comparison of X-Shoulder size issue with MCRD size issue and Test Data size issue with MCRD size issue are displayed in the following table. The across shoulder adjustment should make a difference in the most extreme across shoulder measurements as the table indicates. The overall percentage correct as

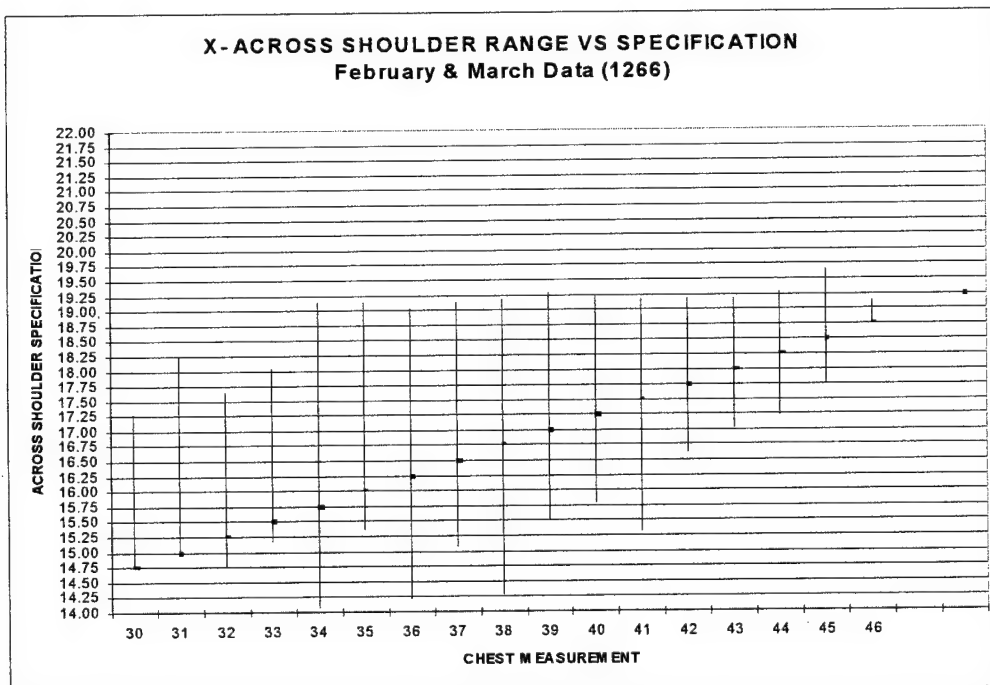
defined by MCRD (+/- 1 size) increased from 83% to 85%. This is a positive trend but the most impact was made with the issues that were farthest from correct. The outcome of X-shoulder size issue resulted in nine +/- 5's and seventeen +/- 4's. The Test Data size issue resulted in zero +/- 5's and twelve +/- 4's and so on. When reading the table results from the bottom to the top, it is apparent that the test data shoulder was moving all of the most extreme issues closer to correct. With further analysis using the ARNScan software to determine results, it may be possible to further improve the results. The possibility of creating two adjustment tables, one to error check standard measurements only and the second to evaluate the shoulders of persons determined to be "athletic build" would further improve the issue of dress coats.

Comparison of X-Shoulder and Test Data Size Selection Results

ARN-MCRD	ARN Size Minus MCRD Size		Accumulative Count		Accumulative Percentage	
	X-Shoulder Across Shoulder	Test Data Across Shoulder	X-Shoulder Across Shoulder	Test Data Across Shoulder	X-Shoulder Across Shoulder	Test Data Across Shoulder
0	733	726	733	726	0.58	0.57
-1	146	174	879	900	0.69	0.71
1	170	180	1049	1080	0.83	0.85
-2	39	62	1088	1142	0.86	0.90
2	102	81	1190	1223	0.94	0.97
-3	12	12	1202	1235	0.95	0.98
3	38	19	1240	1254	0.98	0.99
-4	5	5	1245	1259	0.98	0.99
4	12	7	1257	1266	0.99	1.00
-5	1	0	1258	1266	0.99	1.00
5	8	0	1266	1266	1.00	1.00

The table displays the minimum and maximum across shoulder range used for this analysis. The X-Shoulder is the current measurement being used for size selection by ARNScan. The Test Data is the measurement range determined by the test algorithm for across shoulder adjustment based on chest measurement. As the table and charts indicate, the adjustment algorithm brought the maximum closer to the target across shoulder measurement.

CHEST	Across Shoulder Spec	X-Shoulder Min	X-Shoulder Max	Test Data Min	Test Data Max
0-30-30.49	14.75	17.28	17.28	17.28	17.85
30.5-31-31.49	15.00	16.93	18.23	16.93	17.85
31.5-32-32.49	15.25	14.76	17.64	14.76	17.85
32.5-33-33.49	15.50	15.16	18.03	15.16	17.85
33.5-34-34.49	15.75	14.06	19.13	14.06	17.85
34.5-35-35.49	16.00	15.35	19.13	15.35	17.85
35.5-36-36.49	16.25	14.21	19.02	14.21	17.85
36.5-37-37.49	16.50	15.08	19.13	15.08	18.10
37.5-38-38.49	16.75	14.29	19.17	14.29	18.10
38.5-39-39.49	17.00	15.51	19.29	15.51	18.10
39.5-40-40.49	17.25	15.79	19.21	15.79	18.35
40.5-41-41.49	17.50	15.31	19.17	15.31	18.85
41.5-42-42.49	17.75	16.61	19.17	16.61	18.85
42.5-43-43.49	18.00	17.01	19.17	17.01	19.10
43.5-44-44.49	18.25	17.24	19.29	17.24	19.35
44.5-45-45.49	18.50	17.76	19.65	17.76	19.60
45.5-46-46.49	18.75	18.78	19.13	18.78	19.85
46.5-47-47.49	19.00	NO	DATA	NO	DATA
47.5-48-48.49	19.25	19.21	19.21	19.21	20.35



8.6 ARNScan Session with WBX Scanner at MCRD February - May, 2000

The ARNScan data collected at MCRD, February through May 2000, was received in the standard format on a monthly basis from Cyberware and were then combined in a database for review as one. The database used for evaluation during the month of June had approximately 2030 measurement data sets with complete MCRD size issue data as well as ARNScan size issue with X-shoulder adjustment function.

The measurement range for each chest size, such as 40 (39.5-40-40.49), was evaluated for the across shoulder, waist, and seat. The minimum and maximum for each of these measurements was established for each chest measurement. This will allow the researchers to bar chart each measurement string that is associated with a particular chest measurement and look at the frequency or the number of times this particular size measurement is associated to the chest measurement.

This research will be used as part of the basis for determining a test change to the base pattern. The goal is to determine if a particular target body measurement associated with a chest is actually where the major portion of the population resides. For example, is the seat (hip) of 40 for the size 40 coat actually close to the measurements being gathered at the recruit center. Is the waist of the majority of recruits as small as the pattern indicates? A test change in the pattern will be implemented on paper only after the previous evaluation and used to analysis the rules written for size selection to determine if the alterations required would be affected.

Scan Data Review

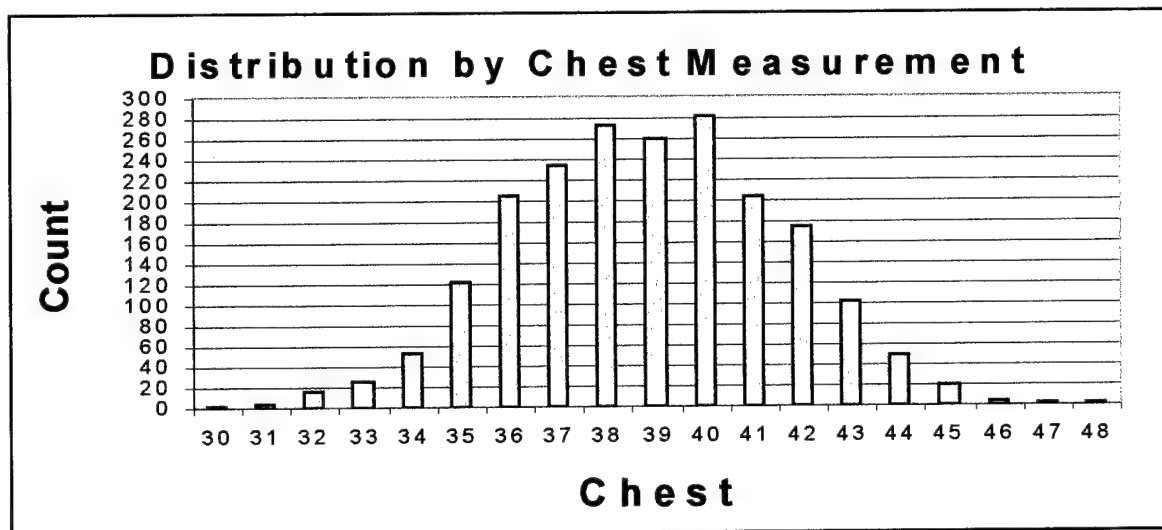
The ARNScan data collected at MCRD, February through May 2000, was combined in a database for review. The database used for evaluation during the month of June and July has approximately 2030 measurement data sets with complete MCRD size issue data as well as ARNScan size issue with X-shoulder adjustment function.

The measurement range for each chest size, such as 40 (39.5-40-40.49), was evaluated for the across shoulder, waist, and seat. The minimum and maximum for each of these measurements was established for each chest measurement. This information is provided in the following tables. Within each measurement range (minimum – maximum) many data points are distributed. This distribution can be displayed in a frequency chart and table. Evaluation of this distribution provides a picture for the researcher to compare the actual measurement frequency or number of times that the particular body measurement is associated with a specific chest measurement and then to the target measurement.

This research will be used as part of the basis for determining a test change to the base pattern. The goal is to determine if a particular target body measurement associated with a chest is actually where the major portion of the population resides.

Minimum and Maximum Measurement

The following tables display the minimum and maximum for each of the specified measurements, across shoulder – waist – seat. The target measurement or specification measurement for each specific chest is also provided. By reviewing the count column the observer can assume that the sample of 2030 appears to be normally distributed in reference to the chest measurement.



Distribution by Chest Measurement

Across Shoulder Minimum and Maximum

Chest Size	CHEST RANGE	X-Shoulder Minimum	X-Shoulder Maximum	Across Shoulder Specification	Count
30	0-30-30.49	16.22	17.28	14.75	2
31	30.5-31-31.49	16.93	18.23	15.00	3
32	31.5-32-32.49	14.76	17.64	15.25	17
33	32.5-33-33.49	15.16	19.06	15.50	26
34	33.5-34-34.49	14.06	19.13	15.75	52
35	34.5-35-35.49	15.20	19.13	16.00	122
36	35.5-36-36.49	14.21	19.09	16.25	205
37	36.5-37-37.49	15.08	19.21	16.50	234
38	37.5-38-38.49	13.15	19.17	16.75	272
39	38.5-39-39.49	13.50	19.29	17.00	260
40	39.5-40-40.49	15.12	20.04	17.25	281
41	40.5-41-41.49	15.31	19.69	17.50	204
42	41.5-42-42.49	16.57	19.61	17.75	174
43	42.5-43-43.49	16.22	19.37	18.00	102
44	43.5-44-44.49	16.46	19.29	18.25	49
45	44.5-45-45.49	17.52	19.65	18.50	20
46	45.5-46-46.49	18.78	19.13	18.75	4
47	46.5-47-47.49	17.91	18.86	19.00	2
48	47.5-48-48.49	19.21	19.21	19.25	1

Waist Minimum and Maximum

Chest Size	CHEST RANGE	Waist Minimum	Waist Maximum	Waist Specification	Count
30	0-30-30.49	23.94	29.76	23.00	2
31	30.5-31-31.49	28.58	29.92	24.00	3
32	31.5-32-32.49	26.77	32.83	25.00	17
33	32.5-33-33.49	26.97	33.86	26.00	26
34	33.5-34-34.49	27.24	33.07	27.00	52
35	34.5-35-35.49	27.83	35.24	28.00	122
36	35.5-36-36.49	27.32	39.25	29.00	205
37	36.5-37-37.49	28.15	35.39	30.00	234
38	37.5-38-38.49	28.15	35.79	31.00	272
39	38.5-39-39.49	28.07	37.20	32.00	260
40	39.5-40-40.49	28.78	38.46	33.00	281
41	40.5-41-41.49	28.94	38.27	34.00	204
42	41.5-42-42.49	31.57	39.76	35.00	174
43	42.5-43-43.49	31.50	39.72	36.00	102
44	43.5-44-44.49	31.46	39.25	37.00	49
45	44.5-45-45.49	35.08	39.72	38.00	20
46	45.5-46-46.49	35.35	39.41	39.00	4
47	46.5-47-47.49	37.40	38.90	40.00	2
48	47.5-48-48.49	37.87	37.87	41.00	1

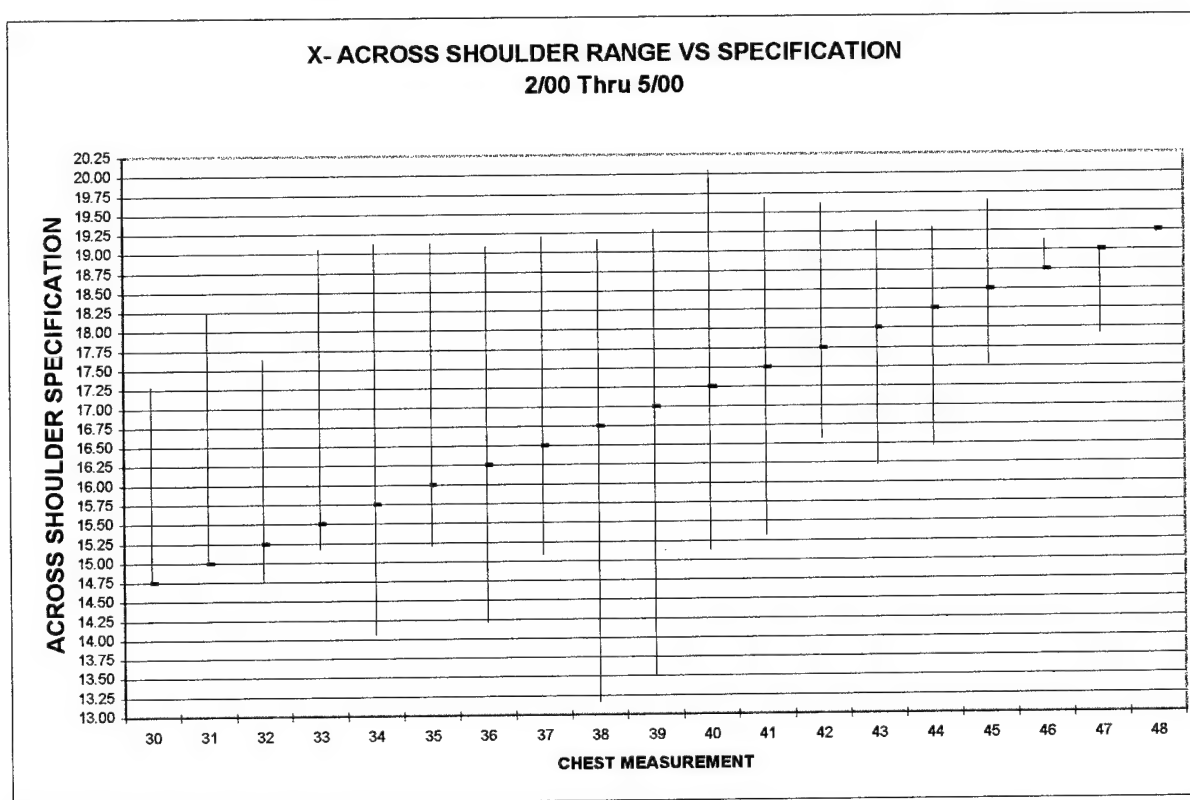
Seat Minimum and Maximum

Chest Size	CHEST RANGE	Seat Minimum	Seat Maximum	Seat Specification	Count
30	0-30-30.49	31.91	35.93	30.00	2
31	30.5-31-31.49	36.04	37.03	31.00	3
32	31.5-32-32.49	32.66	40.81	32.00	17
33	32.5-33-33.49	32.78	38.41	33.00	26
34	33.5-34-34.49	33.72	41.08	34.00	52
35	34.5-35-35.49	32.30	40.97	35.00	122
36	35.5-36-36.49	33.05	43.68	36.00	205
37	36.5-37-37.49	34.63	41.71	37.00	234
38	37.5-38-38.49	34.43	43.60	38.00	272
39	38.5-39-39.49	35.45	44.59	39.00	260
40	39.5-40-40.49	35.65	44.11	40.00	281
41	40.5-41-41.49	36.83	45.53	41.00	204
42	41.5-42-42.49	37.34	48.84	42.00	174
43	42.5-43-43.49	38.17	45.73	43.00	102
44	43.5-44-44.49	39.27	45.34	44.00	49
45	44.5-45-45.49	40.45	44.31	45.00	20
46	45.5-46-46.49	39.19	44.63	46.00	4
47	46.5-47-47.49	41.87	45.45	47.00	2
48	47.5-48-48.49	42.62	42.62	48.00	1

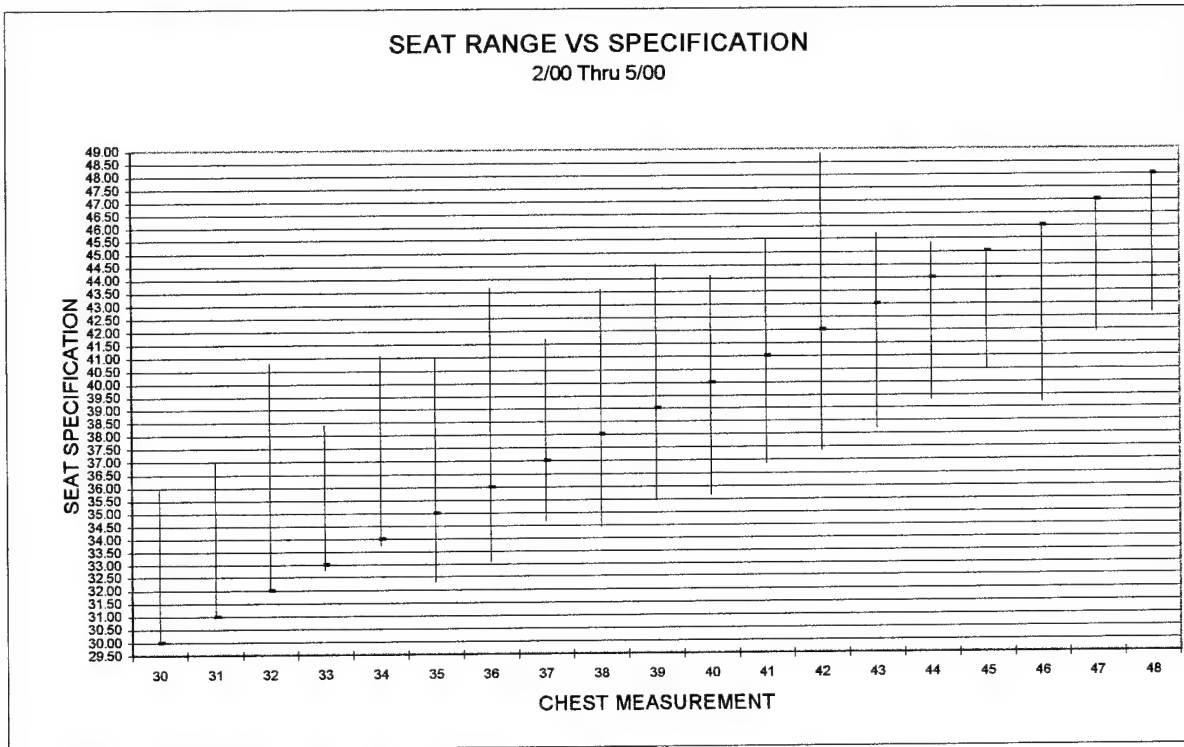
The following charts are the presentation of the data contained in previous tables. The upper and lower end of the bar indicates the minimum and maximum. The dot along the line indicates the across shoulder specification target for that specific chest.

Very few samples were collected on the upper and lower end of the tariff; therefore, the distribution around the target may appear distorted. This is because only one or two points may have been used to determine the minimum or maximum. The largest group of samples is found in the 36 through 43 chest range. These appear to be normally distributed and will be evaluated for measurement point distribution for each chest size.

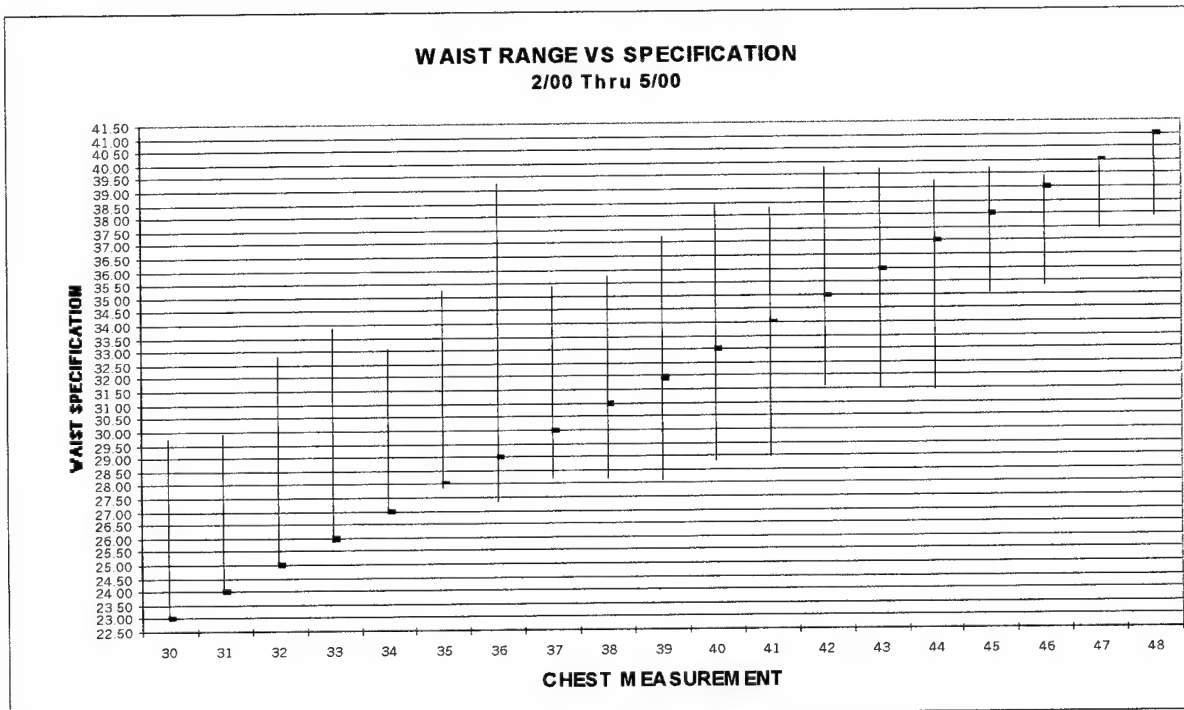
Across Shoulder Range



Waist Measurement Range



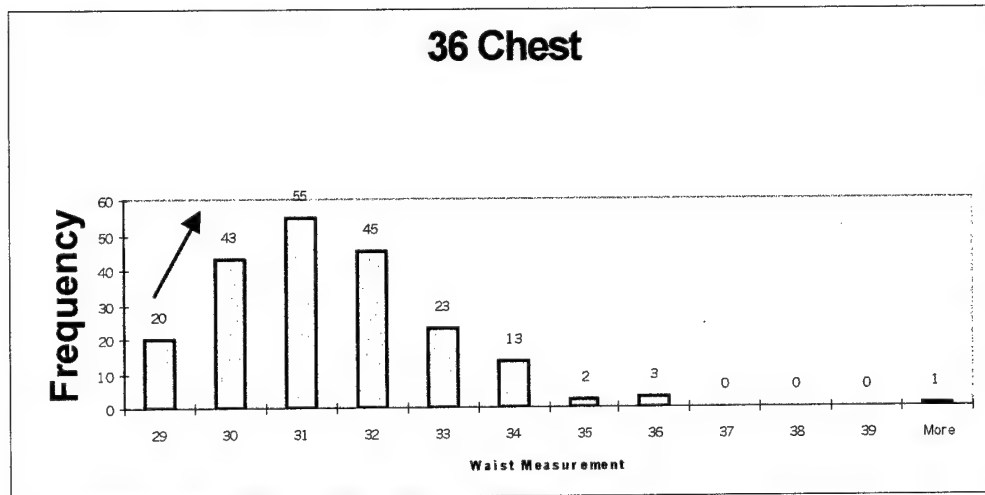
Seat Measurement Range



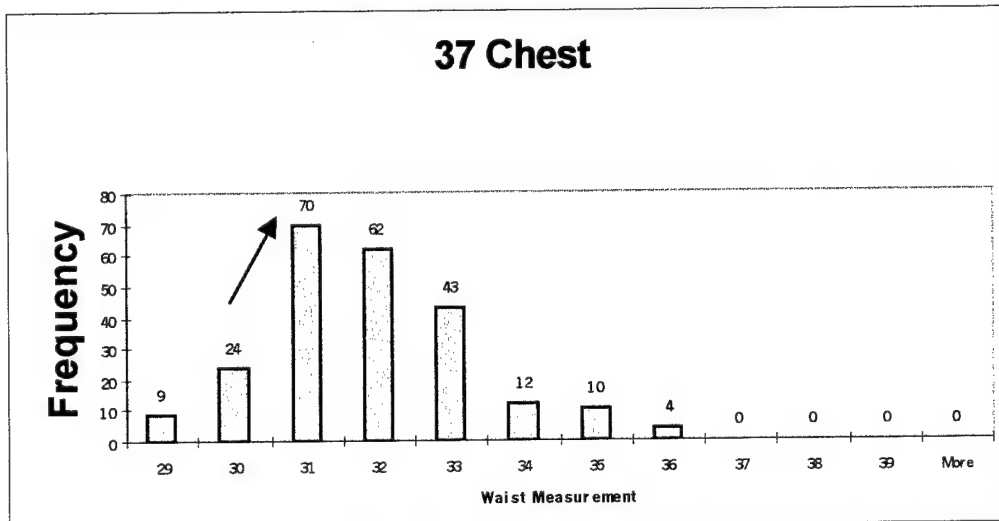
Waist Measurement Point Distribution

The point distribution for the waist body measurement for each specific chest measurement was analyzed for chest measurement 36 through 43. The following Histograms indicate the outcome of this analysis. The Histogram charts are set up for the chest body measurement and the corresponding waist measurements indicated by the sample scan data. The target waist for each chest is indicated in the chart title.

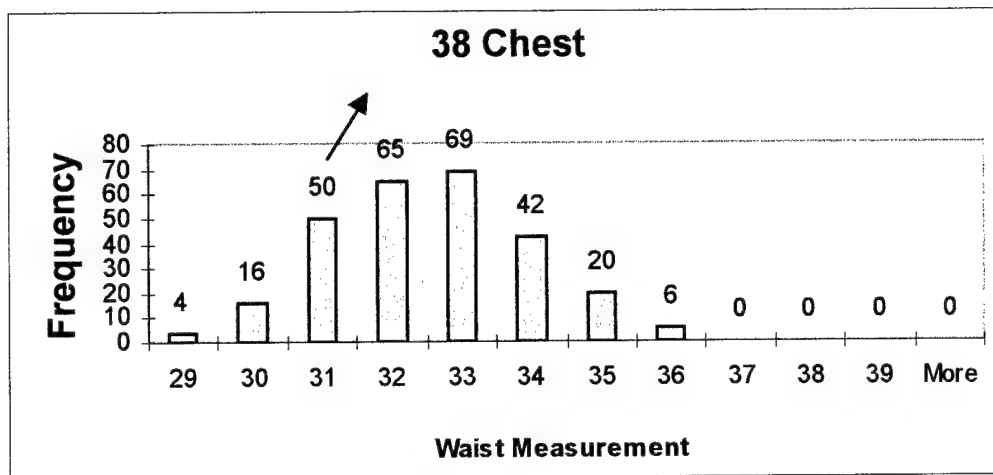
Body Measurement 36 Chest / 29 Waist Target



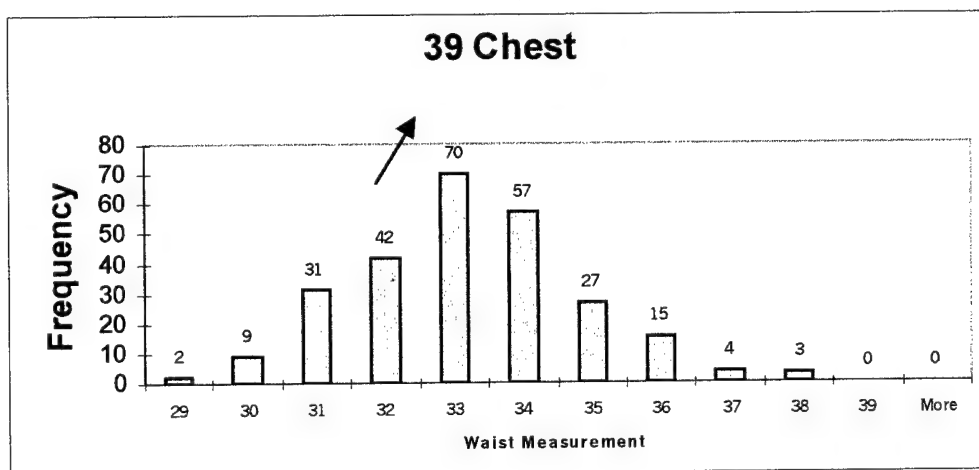
Body Measurement 37 Chest / 30 Waist Target



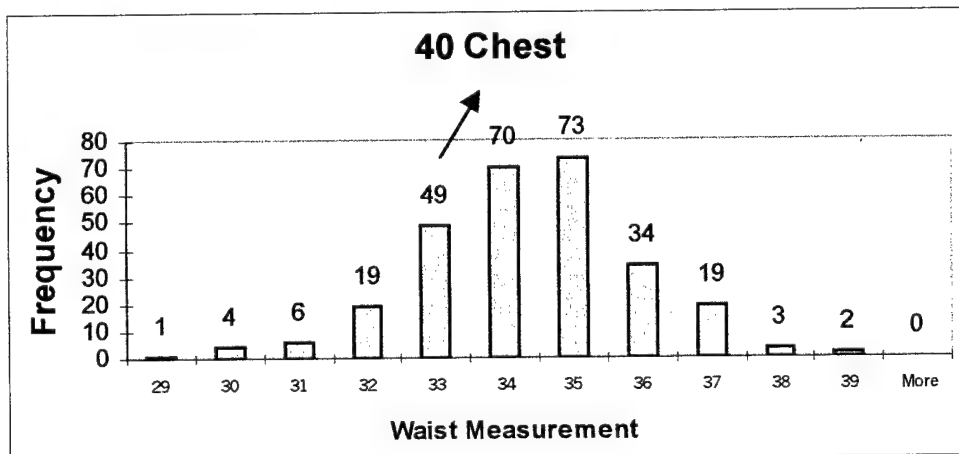
Body Measurement 38 Chest / 31 Waist Target



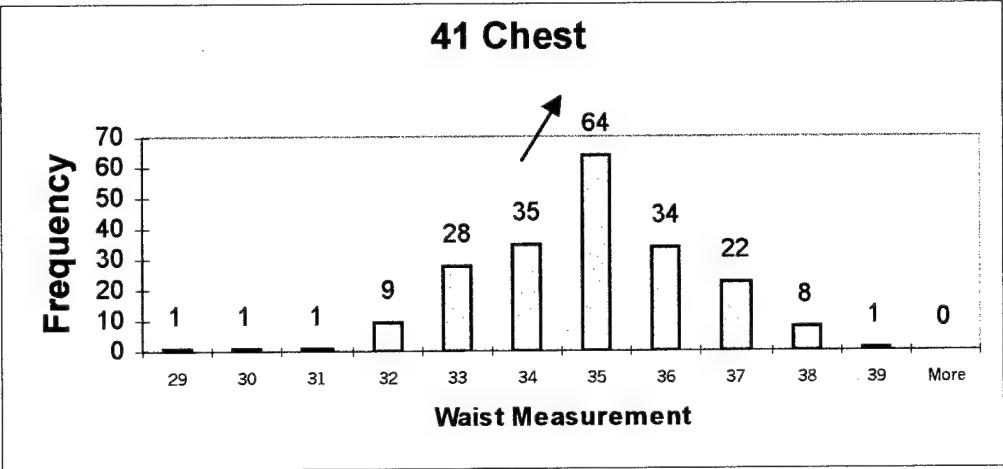
Body Measurement 39 Chest / 32 Waist Target



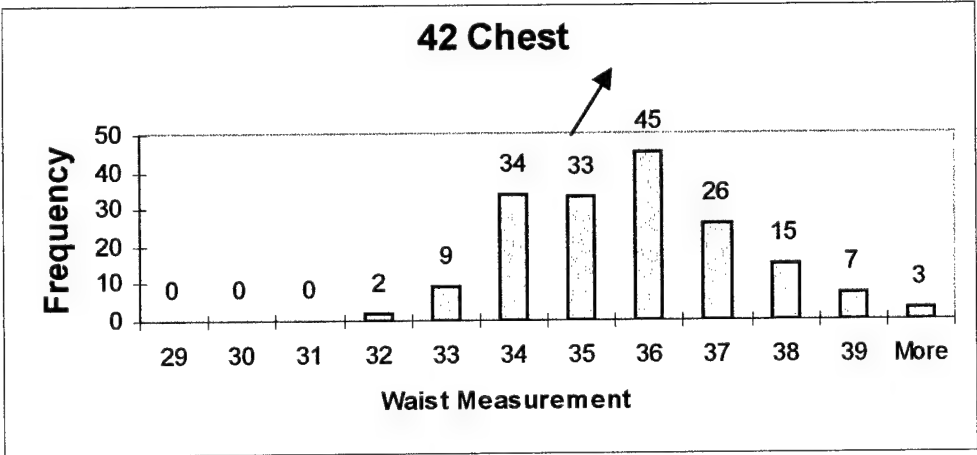
Body Measurement 40 Chest / 33 Waist Target



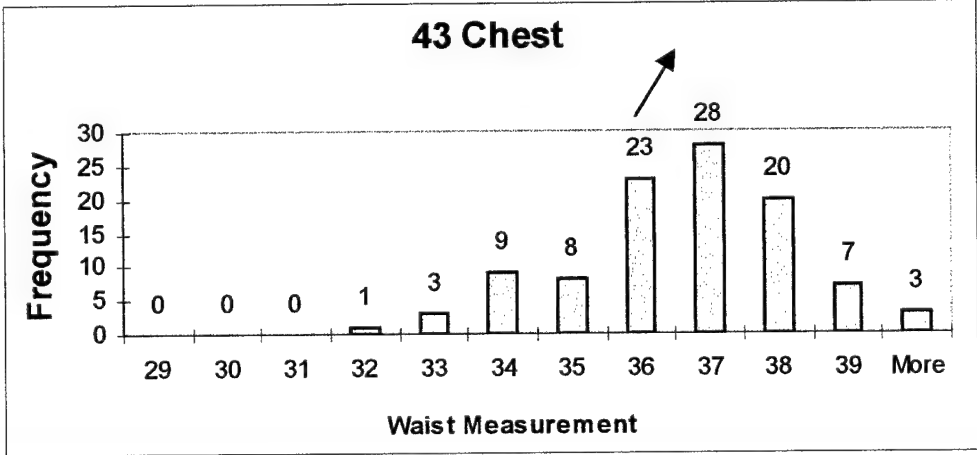
Body Measurement 41 Chest / 34 Waist Target



Body Measurement 42 Chest / 35 Waist Target



Body Measurement 43 Chest / 36 Waist Target



Histogram Analysis

The target for a recruit with a 36-inch chest is 29 inches. As the Histogram indicates only 20 of the 205 data samples was 29 inches or less. The majority of the balance of 185 samples had a chest above the target by 1 to 3 inches.

The target for a recruit with a 37-inch chest is 30 inches. As the Histogram indicates only 33 of the 234 data samples was 30 inches or less. The majority of the balance of 234 samples had a chest above the target by 1 to 3 inches.

The target for a recruit with a 38-inch chest is 31 inches. As the Histogram indicates only 70 of the 272 data samples was 31 inches or less. The majority of the balance of 272 samples had a chest above the target by 1 to 3 inches.

The target for a recruit with a 39-inch chest is 32 inches. As the Histogram indicates only 84 of the 260 data samples was 32 inches or less. The majority of the balance of 260 samples had a chest above the target by 1 to 3 inches.

The target for a recruit with a 40-inch chest is 33 inches. As the Histogram indicates only 79 of the 281 data samples was 33 inches or less. The majority of the balance of 281 samples had a chest above the target by 1 to 3 inches.

The target for a recruit with a 41-inch chest is 34 inches. As the Histogram indicates only 75 of the 204 data samples was 34 inches or less. The majority of the balance of 204 samples had a chest above the target by 1 to 3 inches.

The target for a recruit with a 42-inch chest is 35 inches. As the Histogram indicates only 78 of the 174 data samples was 35 inches or less. The majority of the balance of 174 samples had a chest above the target by 1 to 3 inches.

The target for a recruit with a 43-inch chest is 36 inches. As the Histogram indicates only 44 of the 102 data samples was 36 inches or less. The majority of the balance of 102 samples had a chest above the target by 1 to 3 inches.

In summary of the above analysis, the waist target appears to be smaller than the population scanned indicates by as much as 3 inches. In determining the standard for the population, the goal is to fit the largest number within the scope of the fit standard. The sample data used for this analysis indicates that the waist measurement is larger than expected to fit the design intent of the garments. This assumption will be the premise for further evaluation of the pattern. A test will be conducted with a set of size selection rules revised to imply a larger garment for the target chest. The outcome will be evaluated for better fit and number of alterations.

9.0 REPEATABILITY TEST RESULTS – SIZE SELECTION

Beecher and Ring developed a plan for a repeatability test at Cyberware. Test subjects with various body builds were provided through Cyberware for repeat scanning. The subjects were landmarked and measured using the tape measure to obtain baseline measurement information. Each subject was scanned 10-20 times.

The data obtained from the repeat scanning was analyzed from several viewpoints. Inanimate objects can be scanned multiple times with very little variation but the human body is soft and varies in shape. The information extracted should document how consistent the measurement data is on the same human subject. Some variability is expected. This variability will be evaluated for statistical significance. The measurements from each subject will also be analyzed for size selection variance.

The scans obtained were run through a selection of measurement tools for across shoulder measurement extraction. The researchers will be looking for possible shoulder postures that generate unacceptable measurement data, as well as, which measurement tool is most consistent.

The summary of coat size selection performed during the repeatability test is displayed in the following table. Refer to ST030799IPR for Beecher analysis of data. Each subject was scanned multiple times with size selection being performed with each set of ARNScan body measurements.

Recruit ID	Size Issued	Quantity	Total Scans
Lowe (Manikin)	39	31	31
Hanks	44	30	30
Johnson	44	17	20
	43	3	
Hurt	40	16	20
	39	3	
	41	1	
Beatty	48	20	20
Baldwin	48	4	20
	46	16	
Kline	39	18	19
	38	1	

The following tables' list each scan subject by the range and average of each measurement.

**Beecher Statistics Table
For Measurements Used for Coat Size Selection**

RANGE		Across Shoulder	Chest	Waist	Seat	Height
Lowe	Range	0.336	0.78	0.26	0.14	0
Hanks	Range	0.6144	1.03	0.77	0.34	0.32
Johnson	Range	2.19	1.56	1.21	0.61	0.47
Hurt	Range	0.95	2.72	1.10	0.54	0.31
Beatty	Range	1.60	1.23	1.25	0.73	0.63
Baldwin	Range	1.01	0.69	1.25	0.64	0.39
Kline	Range	0.79	0.89	0.83	0.30	0.31

AVERAGE		Across Shoulder	Chest	Waist	Seat	Height
Lowe	Average	16.94	38.13	31.90	35.02	71.35
Hanks	Average	16.57	42.15	37.93	40.21	75.40
Johnson	Average	16.72	41.07	36.19	38.51	69.80
Hurt	Average	17.10	39.13	32.95	35.14	68.52
Beatty	Average	18.70	46.81	42.35	40.27	69.21
Baldwin	Average	17.33	44.56	41.31	40.95	70.63
Kline	Average	16.31	39.08	31.81	34.24	67.35

Lowe Results

The manikin, Lowe, was scanned a total of 31 times which resulted in the issue of a size 39 for all scan measurement sets. The statistics table included in this report identifies the range of each of the measurements (difference between maximum and minimum). As is indicated in the table, all measurements have some level of variability, even for the manikin. As the Beecher report documents, the manikin was posed in various positions for the scanning session. The results of 31 scans issuing the same size would indicate that the amount of variability in this test did not affect the size selection process.

Hanks Results

Hanks was scanned a total of 30 times resulting in the issue of a size 44 for all scan measurement sets. The range for the measurement sets for Hanks was moderate compared to the other test subjects. The average chest of 42.15 and the average waist 37.93, a 4 inch drop, indicates that Hanks needed a 44 to accommodate the waist measurement. After review of the size selection rules and the given measurement sets, it appears that the large waist measurement drove the size selection.

Johnson Results

Johnson was scanned a total of 20 times resulting in the issue of a size 44 seventeen times and a size 43 three times. The largest range for Johnson was in the measurement for the across shoulder, 2.19. Although the shoulder varied the most it appears that it did not drive the size selection. The range for the chest of 1.56 and the range for the waist of 1.21 were indicators that some size issue variances would happen. After review of the size selection rules and given measurement sets, it appears that the chest and waist drove the size selection on Johnson depending on the combinations of high and low measurements. The waist measurements on the three size 43 coats were smaller than those that selected the size 44.

Hurt Results

Hurt was scanned a total of 20 times resulting in the issue of a size 40 sixteen times, a size 39 three times, and a size 41 one time. The range for the chest of 2.72 was the highest of any of the subjects. A small chest measurement drove the size selection of the size 39 coats and large chest measurement drove the size selection on the size 41 coat. The Beecher section of this report will give more detail on the observations made in reference to the chest measurement tool.

Beatty Results

Beatty was scanned a total of 20 times resulting in the issue of a size 48 for all 20 scan measurement sets. The range for all measurements appeared to be high and are as follows: across shoulder 1.6, chest 1.23, waist 1.25, and seat .73. However, the size issued was consistent on all 20 scans. The average chest of 46.81 and the average waist of 42.35 results in the large waist driving the size selection.

Baldwin Results

Baldwin was scanned a total of 20 times resulting in a size 46 issued 16 times and a size 48 four times. The range for the across shoulder of 1.01 and the waist of 1.25 resulted in combinations that issued the size 46 coats. The average chest of 44.56 and waist of 41.31 drove the size up to the 48 coats issued.

Kline Results

Kline was scanned a total of 19 times resulting in a size 39 issued 18 times and a size 38 one time. The range on all measurements for Kline was the smallest in the scanned group. The average chest of 39.08 and across shoulder of 16.31 drove the size 39 size selection. The minimum shoulder of 15.77 in the scan measurement sets drove the size selection of the size 38 coat.

As detailed throughout this report, variability in measurements is to be expected at some level. The range for each subject varied from measurement to measurement. At this point in the investigation, the reason for large measurement ranges has not been conclusively determined. Some portion of the variation certainly is from the posture and pose of the test subject. Improvement in the areas of software extraction tools should reduce the range to a more manageable number.

It has been discussed throughout this project that a recruit could easily be issued a range of three sizes dependent on the variables included in the issuing process. These variables include software extraction consistency, posture and pose of the recruit during scanning, and the visual observation of fitters/tailors. The posture and pose of the recruit varies during the scanning process as well as during the visual inspection for size selection. The data gathered in this test indicates the range that the measurement data may vary and is a good indicator of how much the ARNScan measurements may vary from the measurements that are visually interpreted by the fitter/tailor.

The size selection documented with this test data provides a size selection range that may be expected with the measurement ranges encountered during this scan session. The sizes issued only varied a +/-1 on all test subjects with the exception of sizes issued where a size was missing in the tariff (46-48).

The test subjects for this scan session were not the typical body shapes or size that would be expected in the recruit induction center. More valid data should be gathered at the appropriate time during a scanning session at MCRD. Subjects could be selectively chosen from the appropriate population and would provide data that could validate the measurement tools/size selection rules or be used in improving the system in the future.

REFERENCE BEECHER INITIAL REPORT STO30799IPR

**Beecher Statistics Table
For Measurements Used for Coat Size
Selection**

Lowe	Across Shoulder	Chest	Waist	Seat	Height
Average	16.94	38.13	31.90	35.02	71.35
Median	16.96	38.14	31.90	35.02	71.35
Std Dev	0.0918	0.175213	0.054819	0.036533	2.2E-06
Maximum	17.10	38.36	32.09	35.10	71.35
Minimum	16.76	37.58	31.83	34.96	71.35
Range	0.336	0.78	0.26	0.14	0
Count	31	31	31	31	31
Hanks	Across Shoulder	Chest	Waist	Seat	Height
Average	16.57	42.15	37.93	40.21	75.40
Median	16.57	42.15	37.93	40.19	75.38
Std Dev	0.171687	0.255925	0.175661	0.079238	0.099742
Maximum	16.89	42.60	38.35	40.41	75.53
Minimum	16.27	41.57	37.58	40.07	75.21
Range	0.6144	1.03	0.77	0.34	0.32
Count	20	20	20	20	20
Johnson	Across Shoulder	Chest	Waist	Seat	Height
Average	16.72	41.07	36.19	38.51	69.80
Median	16.46	42.00	37.80	40.17	70.49
Std Dev	0.542724	0.36215	0.307364	0.159779	0.127935
Maximum	17.62	42.78	38.56	40.51	70.56
Minimum	15.43	41.22	37.35	39.90	70.09
Range	2.19	1.56	1.21	0.61	0.47
Count	20	20	20	20	20
Hurt	Across Shoulder	Chest	Waist	Seat	Height
Average	17.10	39.13	32.95	35.14	68.52
Median	17.06	38.99	33.05	35.10	68.54
Std Dev	0.215078	0.649914	0.307937	0.141886	0.091437
Maximum	17.55	41.05	33.44	35.46	68.67
Minimum	16.60	38.33	32.34	34.92	68.36
Range	0.95	2.72	1.10	0.54	0.31
Count	20	20	20	20	20
Beatty	Across Shoulder	Chest	Waist	Seat	Height
Average	18.70	46.81	42.35	40.27	69.21
Median	18.68	46.83	42.35	40.27	69.25
Std Dev	0.450451	0.345861	0.361987	0.209398	0.200349
Maximum	19.38	47.30	42.98	40.63	69.46
Minimum	17.78	46.07	41.73	39.90	68.83
Range	1.60	1.23	1.25	0.73	0.63
Count	20	20	20	20	20
Baldwin	Across Shoulder	Chest	Waist	Seat	Height
Average	17.33	44.56	41.31	40.95	70.63
Median	17.23	44.59	41.28	41.00	70.64
Std Dev	0.265391	0.224441	0.318289	0.193894	0.132993
Maximum	17.87	44.88	42.06	41.22	70.80
Minimum	16.86	44.19	40.81	40.58	70.41
Range	1.01	0.69	1.25	0.64	0.39
Count	20	20	20	20	20
Kline	Across Shoulder	Chest	Waist	Seat	Height
Average	16.31	39.08	31.81	34.24	67.35
Median	16.35	38.99	31.81	34.22	67.34
Std Dev	0.201682	0.248817	0.219525	0.082011	0.063333
Maximum	16.56	39.61	32.19	34.41	67.49
Minimum	15.77	38.72	31.36	34.11	67.18
Range	0.79	0.89	0.83	0.30	0.31
Count	19	19	19	19	19
Note: Revised M. Across Shoulder Function Predict Waist Function Lowe is a manikin					

10.0 ERROR CHECKING ALGORITHM

As described in earlier reports, the across shoulder measurement appears to be the most inconsistent of measurements extracted by ARNScan. Although across shoulder is one of the most critical measurements in coat fitting, the data implies that the range of fit is much larger than what would be expected if a custom fit coat were being fitted. Therefore, the across shoulder is not the only measurement that may drive the size

selection. As the chest, waist, or seat increases or decreases by 1", the across shoulder increases or decreases by 1/4". Therefore, the error in across shoulder measurements effects the size selection more quickly.

The coat issues that were beyond the accepted +/- 1 size were analyzed for extreme measurements. SPSU and Beecher recommended to Cyberware that an algorithm which placed a limit on the across shoulder measurements be included in the ARNScan software. The across shoulder measurement would be limited to a reasonable measurement as compared to the chest.

SPSU developed a test algorithm in Excel using the across shoulder as a percentage of the chest. The test algorithm was used to evaluate the size selection process utilizing an acceptable across shoulder measurement. The measurement obtained from ARNScan would be evaluated to see if it was within an acceptable upper and lower percent range for that specific chest measurement.

The algorithm is as follows:

If (across shoulder/chest) <= lowest percent allowed then across shoulder measurement equals chest times lowest percent

If (across shoulder/chest) > lowest percent allowed and if (across shoulder/chest) is < highest percent allowed then across shoulder measurement equals across shoulder measurement

If (across shoulder/chest) >= highest percent allowed then across shoulder equals chest times highest percent

The limits for each chest range are still being evaluated. Beecher generated data from an ANSUR database that will be used as a baseline for the limits. This process is still in progress. Information developed during this process will be provided to Cyberware for incorporation into ARNScan software.

As a task to be performed later, error checking for all measurements is recommended to be incorporated into ARNScan software.

A sample of the preliminary test data for the across shoulder limits is provided in the following table.

Across Shoulder Limit Test Data Sample

		COAT					ANScan Adjusted Body Measurements				Coat Size Measurement Fits				Test Measurements percent range limits =<39 % - 49%>= IF (H4/I4<=0.39,I4*0.39,IF (H4/I4>0.39,IF (H4/I4<0.49,H4,IF (H4/I4>=0.49,I4*0.49))))			
dbn ID #	ARN Coat	C - L	MCRD Coat	C - L	ARN-MCRD	A - M	across shoulder	chest	waist	seat	Across Shoulder	Chest	Waist	Seat	shld/ chest	Accept across shoulder	Size selection with shoulder statement	Comments on new results
1	40	3	42	2	-2	1	14.86	40.19	33.20	39.43	30-31	40-41	40-41	39-40	37%	15.67	same	across shoulder = chest * low percent limit
2	44	3	44	3	0	0	17.11	44.46	36.11	39.42	39-40	44-45	43-44	39-40	38%	17.34	same	across shoulder = chest * low percent limit
3	39	1	41	1	-2	0	15.29	38.19	33.26	36.84	32	38-39	40-41	36-37	40%	15.29	same	across shoulder = across shoulder
4	44	3	40	3	4	0	19.24	38.06	31.32	38.03	48	38	38-39	38	51%	18.65	42 issue vs 44 better by 2 sizes	across shoulder = chest * high percent limit
5	41	1	39	0	2	1	18.38	36.23	30.48	37.04	44-45	36-37	37-38	37	51%	17.75	39 issue vs 41 better by 2 sizes	across shoulder = chest * high percent limit

The ID sample 1 and 2 have across shoulders below the allowed 39%, therefore the across shoulder is recalculated. Even though the across shoulders were changed to acceptable measurement, 14.86 to 15.67 and 17.11 to 17.34, the outcome of size selection did not change. On ID sample 3 the across shoulders fell within the acceptable limits and therefore the across shoulder measurement did not change.

The ID samples 4 and 5 have across shoulders higher than the upper limit of 49% and therefore were recalculated. Sample 4 across shoulder of 19.24 was reduced to 18.65 due to recalculation. ARNScan originally issued a 44 verses a 40 from MCRD. The new across shoulder measurement reduced the difference from a +4 sizes to +2. Sample 5 also showed an improvement of 2 sizes due to the recalculated across shoulder.

This data is from preliminary limits. Only one limit was used for the entire tariff of sizes. A range of limits will be reviewed to see which give the best results based on multiple percentage ranges. This information will be provided to Cyberware for creation of a routine to run this error check before measurements are used to generate size selection. This process should be invisible to the user and should not impact the processing time significantly.

Shirt Data Analysis

Analysis of the shirt data continued. The following table indicates the type of data table constructed used in evaluation of size selection.

				ARNScan Measurement				ARN Garment Measurement			ARNScan Ease			MCRD Garment Measurement			MCRD Ease		
dbn	ARN Shirt	MCRD Shirt	ARN - MCRD	neck	across shoulder	chest	sleeve	neck	across shoulder	chest	neck	across shoulder	chest	neck	across shoulder	chest	neck	across shoulder	chest
1	15.5	15.5	0	15.01	17.32	35.83	31.13	16.0	18.5	45	0.49	1.18	9.17	16.0	18.5	45	0.49	1.18	9.17
2	15.5	16	-0.5	15.06	16.49	35.06	34.62	16.0	18.5	45	0.44	2.01	9.94	16.5	19.0	47	0.94	2.51	11.94
3	16	15.5	0.5	14.87	17.26	39.36	33.24	16.5	19.0	47	1.13	1.74	7.64	16.0	18.5	45	0.63	1.24	5.64
4	16	15.5	0.5	14.89	17.26	38.95	34.35	16.5	19.0	47	1.11	1.74	8.05	16.0	18.5	45	0.61	1.24	6.05
5	16	16	0	14.97	17.50	39.08	32.80	16.5	19.0	47	1.03	1.50	7.92	16.5	19.0	47	1.03	1.50	7.92

Sample data number 1 and 2 were compared to determine if there was consistency in size issue. In this example ARNScan issued a 15.5 for both, but MCRD issued a 15.5 and 16. The analysis of the measurement data did not result in any specific reason for the difference in issue. All of the measurements fell within allowed measurement ranges in the ARNScan rules. There was not any justification from the measurement data alone for the different size issued by MCRD. Sample 1 was issued a 15.5 and sample 2 was issued a larger size of 16 by MCRD. The measurements indicate that the neck was the same ($15.01 > 15.06$), the across shoulder on the 15.5 issued was actually larger than the one issued the 16, ($17.32 > 16.49$), as was the chest ($35.83 > 35.06$).

Sample data number 3, 4, and 5 were compared and resulted in the same determination as sample 1 and 2. There was not any measurement data that indicated that a different size should be issued to sample number 5. The analysis of the 157 recruits from the May scan sessions were evaluated in the same manner as the sample given.

A controlled size selection test is scheduled for each of the dress items including the shirt for August/September. This data should be more consistent and information gathered by the researchers from the tailor may provide information that would confirm and/or improve the size selection tables.

11.0 SCAN DATA REVIEW FOR PATTERN CHANGE

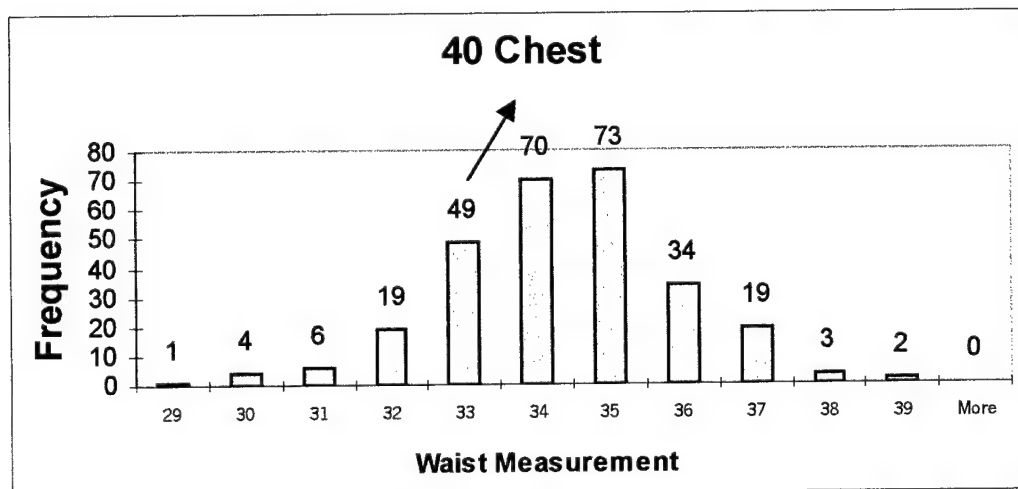
There are 2030 measurement sets collected by ARNScan at MCRD during February through May 2000 with MCRD size issue data, as well as ARNScan size issue. This database was sorted by measurement range for each chest size, such as 40 (39.5-40-40.49), for evaluation. The minimum and maximum for each of the collected measurements was established for each chest measurement. This information is provided in previous sections of this report.

Within each measurement range (minimum – maximum) many data points are distributed. This distribution was displayed in a frequency chart and table. Evaluation of this distribution provides a picture for the researcher to compare the actual measurement frequency or number of times that the particular body measurement is associated with a specific chest measurement and then to the target measurement. This information was used as the basis to test the results of a simulated waist change in the pattern.

The evaluation of each of these distributions indicated that the majority of waist measurements are 1 to 3 inches larger than the target. In determining the standard for the population, the goal is to fit the largest number within the scope of the fit standard. The sample data used for this analysis indicates that the waist measurement is larger than expected to fit the design intent of the garments. This assumption will be the premise for further evaluation of the pattern.

The size 40 chest range (39.5 – 40 – 40.49) was used for this test. The database was sorted and the group of 323 subjects within this test measurement range was used to create a separate test list. The following chart indicates the waist distribution for this sample group.

Body Measurement 40 Chest / 33 Waist Target



A test was conducted with a set of size selection rules revised to imply a one-inch larger garment for the size 40-chest garment. The sizes were manually selected and the outcomes summarized. Of the total, 246 size issues did not change. This indicates that the waist was not the measurement driving the size selection. A total of 77 sizes issued were reduced by 1 size. The ease stayed the same in these cases because the garment waist had been increased for this test by 1 size or 1 inch in measurement. The results did not lead the researchers to any specific conclusions.

The 246 data sets that remained the same were further evaluated. The simulated waist change was reduced to ½ inch and a range set for the decision to alter or not alter. The alteration test range was set as follows:

- Waist ease 0 – 2 inches alter to increase ease
- Waist ease 2 – 3.5 inches accept ease
- Waist ease 3.5 and greater alter to reduce ease

The ease amount, difference between garment issued waist dimension and the body waist measurement, was sorted and a decision for alter or no alter made. The results were summarized for the actual ARNScan size issue, Test issue assuming ½" increase in waist, and the MCRD actual size issued waist ease. The results in the following table indicate that an increase in the waist of the garment would lead to additional alterations for the test data.

The data is summarized in count and also in percentages. MCRD size issue data was available for only 197 of the 246 data sets; therefore percentages allowed a better comparison to the ARNScan results. There was an increase of 6% in alterations based on the garment waist change for the test base. The comparison of the actual ARN issue and the MCRD issue indicates that the percentage of alterations at approximately 64 percent, was the same for ARN and MCRD. This would be expected because the size selection rules were written to match the MCRD actual issue as close as possible.

PATTERN INCREASE AT WAIST 1/2 INCH

	ARN ALTERATION	TEST ALTERATION	MCRD ALTERATION
NO	89	73	70
YES	157	173	127
TOTAL	246	246	197
NO %	0.3618	0.2967	0.3553
YES %	0.6382	0.7033	0.6447

The results were not consistent with the expected results based on the waist measurement distribution displayed in the bar chart. The sizes issued by MCRD for the test chest measurement range of 40 (39.5 – 40 – 40.49) were reviewed to determine why the results were not as expected.

The count by size and the minimum and maximum waist ease actually issued are summarized in the following table.

Chest Measurement 39.51" - 40.49"

ISSUE SIZE CHEST	COUNT	Waist Ease	
		MINIMUM	MAXIMUM
39	2	1.23	2.37
40	37	-0.76	6.72
41	63	1.30	6.93
42	87	0.65	6.44
43	53	1.22	8.15
44	19	2.10	6.94
46	3	3.43	8.15

In summary, the review of the size distribution issued by MCRD indicates that larger sizes are being issued for the chest measurement than expected based on the target fit ease. The range of chest measurements in this test group indicate a size 40 coat although the data indicates that the majority of the subjects were issued 1 to 3 sizes larger. The larger size could be driven by the fit at the shoulder or the seat for certain subjects. But the overall issue prospective at MCRD is that larger is better and the size selection rules have been generated to imitate the MCRD fit criteria. This is not to say that the size issued is wrong. It does indicate that an evaluation for pattern change is much more complex than looking at measurements only.

It is appropriate to state that the waist measurements indicate that the pattern waist for the chest measurement is smaller than the population indicates that it should be. But evaluation of the actual size issued indicates that based on the size issue preference the pattern should not be changed. A much more detailed analysis including the prospective of the group determining the actual size issued would be necessary for further investigation.

12.0 SIZE SELECTION RULE METHODOLOGY

12.1 Coat Rule Methodology

The Marine Service Coat size selection tables were generated taking into consideration the design intent, tailoring and alteration information gathered at MCRD San Diego, and effectiveness based on actual sizes issued at MCRD. The measurement ranges were determined utilizing the finished garment dimensions and the standard body measurements the designer intended for the garment to fit. Fit ease (garment minus body measurement) built into the garment by the designer was determined and used as the target for the issued stock garment and the altered garment.

The following table outlines the standard ease expected to meet the Marine Corp desired fit. If the body measurement silhouette provided by ARNScan fit within these ease requirements, no alterations would be necessary. At this date, no recruit in the scanned data sample being used in the evaluation process fit perfectly into this range. This is to be expected. Body measurement charts are only a target; very few humans fit the measurements exactly. For this reason, an acceptable body measurement range

is necessary. When a measurement or group of measurements do not fit in the standard fit range, alterations may be necessary.

The following table also outlines the alterations performed by the tailor to reduce the selected garment or to increase the selected garment. The maximum reduction or increase on chest, waist, and seat measurement are detailed. No alterations are described for the across shoulder measurement. Unless the garment is being "remodeled" for the most extreme cases, the across shoulder is not generally altered. This is the most critical area of the dress coat and is not easily altered. Therefore, it is only in special cases that an alteration is performed.

MC Service Coat Standard Ease and Alteration Allowances

MARINE MAN'S COAT SIZE SELECTION RULES MIL-C-29424A			
Across shoulder	Chest	Waist	Seat
Standard Ease 1"	Standard Ease 2"	Standard Ease 2.5"	Standard Ease 2"
Note: Ease = Garment measurement minus body measurement			
Maximum Reduction Alteration Allowed			
Across shoulder	Chest	Waist	Seat
None except in extreme cases	Maximum 2.5 inch reduction at underarm	Maximum 2.5 inch at sideseam	maximum 2.5 inch at sideseam
Back center seam adjusted to reduce across back reduces fullness due to excess shoulder ease	Maximum 1.5 inch reduction at centerback seam	Maximum 2.5 inch at front (dart under pocket and gathering)	maximum 2.5 inch reduction by gathering of skirt
		Reduce .5 by moving button	
		(worn over pant 1.00 reduction for waistband)	
Maximum Increase Alteration Allowed			
Across shoulder	Chest	Waist	Seat
None	Maximum 2.0 inch increase at underarm and centerback	Maximum 1.5 inch increase at sideseam	maximum 1.5 inch increase at sideseam
		Increase .5 inch by moving button	increase 1.0 inch at overlap in front skirt

The coat size selection table was modified to include a rule size code. This allowed review of scan data based on the rule code that issued the size. This table includes the rule code and the body measurement range for each of the rules as they apply to the size 40 service coat.

Marine Service Size 40 Coat: Size Selection Rule Code Body Measurement Range

Rule Code	Across Shoulder		Chest		Waist		Seat	
S	16.75	17.75	39.5	40.5	32.5	33.5	39.5	40.5
S1A	16.25	18.00	37.5	40	31.5	33.5	37.5	40
S2A	16.25	18.00	36	40	28	33.5	35	40
R	16.00	18.25	36	41	28	34.5	35	41.5
1R	15.75	18.25	35	41	27	34.5	34	41.5
2R	15.50	18.25	34	41	26	34.5	33	41.5
3R	15.25	18.25	33	41	25	34.5	32	41.5
4R	0.00	18.25	0	41	0	34.5	0	41.5
5R	0.00	19.25	0	44	0	37.5	0	44.5

This table describes the methodology used in generating each of the rule sets. The first rule (S) is the perfect fit. Most body measurement sets will not meet this rule requirement. It was included because it is the starting point for all other rules and some small percentage of the target population may meet the range requirements.

The tailor would rather perform alterations for reducing the size of the garment if possible because the final altered garment will generally provide a cleaner and better final appearance when worn. Therefore Rule S1A allows minor reduction alterations and no increasing alterations. All measurement sets that issue a size based on Rule S1A will not necessarily require an alteration. This will depend on the combination of measurements. The accepted ease range is larger than the standard target. For example if the chest measurement was smaller by .5 inches than the minimum allowed on Rule S the size selection would be from Rule S1A. The chest ease would be 2.5 inches and would be acceptable without alteration.

Rule S2A allows the maximum alterations in the chest, waist, and seat. It does not allow increase alterations, just as Rule S1A. The allowed alterations do not include increase alterations until Rule R. The preference would be that all body measurements sets fall in Rule R or below. All garments issued within these rule ranges would allow for alterations that could generate garments that fit within the target ease range.

The body measurement ranges in Rule 1R through Rule 3R are increased incrementally by 1" in the maximum ease. The garments issued by these rules when altered by the

traditional methods and maximums will not provide garments that meet the target ease. The garments will fit with more ease than expected but are acceptable in most cases. The rules are written in a hierarchy of best fit, least amount of reduction alteration, least amount of increase alteration, and best size for measurement sets that will yield the closest to the target ease.

Rules 4R and 5R are included for the most extreme measurement ranges. These measurement sets are the farthest from the silhouette the garments were designed to fit appropriately. They may require "remodeling" the garment. The changes necessary are well beyond alterations. Basically the tailor is building a garment with the remnants of a stock coat fabric. This is only necessary in the most extreme cases but must be included in the rule set.

Coat Size Selection Rule Methodology

Rule Code	Allowed Garment Reduction and Increase Alterations
S	<ul style="list-style-type: none"> ◆ No Alteration- Exact Body Measurements to Fit Coat Design Intent
S1A	<ul style="list-style-type: none"> ◆ Minor Garment Alterations to Reduce Coat for any combination of Chest, Waist, Seat ◆ No Garment Increase Alterations Allowed ◆ Across Shoulder Ease allowed .5" more than standard
S2A	<ul style="list-style-type: none"> ◆ Maximum Garment Alterations to Reduce Coat for any combination of Chest, Waist, Seat ◆ No Garment Increase Alterations Allowed ◆ Across Shoulder Ease Range same as rule S1A
R	<ul style="list-style-type: none"> ◆ Maximum Garment Alterations to Reduce Coat for any combination of Chest, Waist, Seat ◆ Minor Garment Alterations to Increase Coat for any combination of Chest, Waist, Seat ◆ Across Shoulder Ease Range increased by .25"
1R	<ul style="list-style-type: none"> ◆ Maximum Garment Reduction Alterations Range Increased by 1" for any combination of Chest, Waist, Seat (1" more than allowed in rule R) ◆ Minor Garment Alterations Range to Increase Coat for any combination of Chest, Waist, Seat (Stayed Same as in rule R) ◆ Across Shoulder Ease Range increased by .25"
2R	<ul style="list-style-type: none"> ◆ Maximum Garment Reduction Alterations Range Increased by 2" for any combination of Chest, Waist, Seat (2" more than allowed in rule R) ◆ Minor Garment Alterations Range to Increase Coat for any combination of Chest, Waist, Seat (Stayed Same as in rule R) ◆ Across Shoulder Ease Range increased by .25"
3R	<ul style="list-style-type: none"> ◆ Maximum Garment Reduction Alterations Range Increased by 3" for any combination of Chest, Waist, Seat (3" more than allowed in rule R) ◆ Minor Garment Alterations Range to Increase Coat for any combination of Chest, Waist, Seat (Stayed Same as in rule R) ◆ Across Shoulder Ease Range increased by .25"
4R	<ul style="list-style-type: none"> ◆ Captures Any Combination of Measurements That Did Not Receive a Size Issue from Previous Rules (May require major rebuilding of coat due to lack of correlation of measurements to the normal silhouette. Measurements did not fall in previous range because one or more measurements are extremely large or small. Case: Extremely large across shoulder as compared to out of the normal small seat.) ◆ Minor Garment Alterations Range to Increase Coat for any combination of Chest, Waist, Seat (Stayed Same as in rule R) ◆ In most cases the coat will not meet the required ease allowances for all measurements after alteration but will be determined acceptable.
5R	<ul style="list-style-type: none"> ◆ Issues Sizes for Measurement Combinations Which Did Not Fit in Previous Rule Range

Comment Printed: Out of any alteration limit.

- ◆ These garments will require what the tailor terms as "coat remodeling". Takes fabric from stock coat to make a special fit.
- ◆ In most cases the coat will not meet the required ease allowances for all measurements but will be determined to be acceptable.

Rule Code Distribution: May 1999 Scan Data

Rule Code	Quantity	Rule Code	Quantity
S	0	1R	10
S1A	47	2R	3
S2A	55	3R	3
R	29	4R	9
		5R	0

The distribution of size selection by Rule Code was evaluated. The garments issued using Rule 4R were analyzed. It was determined that most of these body measurement sets had at least one extraneous body measurement that was very far from the norm. These scans were discovered in previous analysis as scans that were not accurate due to unusual digitize points (seat and across shoulder). This issue was corrected and future scans did not have this problem. The 9 scans that issued using Rule 4R was much higher than what is expected. The total scans of 150 excluding the unusual scans from Rule 4R were determined to be distributed as expected based on previous evaluations.

A total of 88% of the sizes issued were within the standard alterable range of Rule S through Rule R. An additional 7% (Rule 1R) were within the alterable range allowing a larger acceptable ease allowance. Therefore, a total of 95% of the 150 scans were within the norm expected. The size selection rules appear to be issuing appropriately with the test body measurement sets. One criteria used in the generation of the size selection rule table was the number of sizes issued that matched MCRD. As the measurement extraction software is modified the rules require reevaluation and may need minor modification to achieve the best outcome.

12.2 Trouser Rule Methodology

The Marine Service Trouser size selection tables were generated taking into consideration the design intent, tailoring and alteration information gathered at MCRD San Diego, and effectiveness based on actual sizes issued at MCRD. The measurement ranges were determined utilizing the finished garment dimensions and the standard body measurements the designer intended for the garment to fit. Fit ease (garment minus body measurement) built into the garment by the designer was determined and used as the target for the issued stock garment and the altered garment.

The following table outlines the standard ease expected to meet the Marine Corp desired fit. If the body measurement silhouette provided by ARNScan fit within these ease requirements, no alterations would be necessary. When the subjects do not fit into the preferred ease range, an acceptable body measurement range is necessary. When a measurement or group of measurements do not fit in the standard fit range, alterations may be necessary. The table also outlines the alterations performed by the tailor to reduce the selected garment or to increase the selected garment. The maximum reduction or increase on seat and waist measurement are detailed.

MC Service Trousers Standard Ease and Alteration Allowances

MARINE MEN'S TROUSER SELECTION RULES MIL-T-29452A	
Seat	Waist
Standard Ease 3"	Standard Ease 1"
Note: Ease = Garment measurement minus body measurement	
Maximum Reduction Alteration Allowed	
Seat Maximum 1.0 inch reduction at back seat seam	Waist Maximum 1.75 inch reduction at center back waist
Maximum Increase Alteration Allowed	
Seat Maximum 1.0 inch increase at back seat seam	Waist Maximum 1.75 inch increase at center back waist

The trouser size selection table was modified to include a rule size code. This allowed review of scan data based on the rule code that issued the size. The table includes the rule code and the body measurement range for each of the rules as they apply to the size 34 service trousers.

The body measurement determined to be the standard for the size 34 trousers was a 33 body waist measurement and a 40 body seat measurement. The fit instructions describe the size selection to be based on the actual waist body measurement plus 1 inch to indicate the size to be issued. Therefore the size 34 trousers is fitted to the 33 waist body measurement.

Marine Service Size 34 Trouser:
Size Selection Rule Code Body Measurement Range

Rule Code	Seat		Waist	
1S	39.5	40.5	32.50	33.50
2S	38.5	39.5	32.50	33.50
3S	39.5	40.5	31.25	32.50
4S	38.5	39.5	33.50	34.75
5S	40.5	41.5	31.00	32.25
1R	37.5	38.5	33.75	34.75
2R	36.5	37.5	33.75	34.75
3R	41.5	42.5	31.00	32.25
MS P	41.5	42.5	3.00	34.00
PSP	36.5	37.5	34.75	100.00

Marine Service Size 34 Trouser:
Size Selection Rule Code Ease Range

Rule Code	Seat		Waist	
1S	2.5	3.5	0.50	1.50
2S	3.5	4.5	0.50	1.50
3S	2.5	3.5	1.50	2.75
4S	3.5	4.5	-0.75	0.50
5S	1.5	2.5	1.75	3.00
1R	4.5	5.5	-0.75	0.25
2R	5.5	6.5	-0.75	0.25
3R	0.5	1.5	1.75	3.00
MS P	0.5	1.5	3.00	34.0
PSP	5.5	6.5	-66.0	-0.75

The table indicates the ease range associated with the size selection rule code. The methodology used in generating each of the rule sets was based on the information collected at MCRD and fit information provided by the official fit manual and is as follows:

- ◆ The first rule (1S) is the perfect fit. It will accommodate the design target silhouette only. Many body measurement sets will not meet this rule requirement. It is at the beginning of the rule structure and is the starting point for all other rules.
- ◆ The fit instructions recommend going up a size to meet the waist measurement if it is larger than standard for the seat measurement, therefore reducing alterations. Rule 2S is the next preferred fit, allowing 1-inch additional ease in the seat to accommodate the larger waist without alteration. Note that the waist ease is still in the preferred range without alteration.
- ◆ Rule 3S accommodates the standard seat ease but allows a larger amount of ease in the waist, which may require a reduction alteration. The tailor prefers to decrease the waist ease to increasing the seat ease by alteration if possible. This provides for a better looking finished garment after alteration.
- ◆ Additional ease of 1 inch in the seat is allowed in rule 4S without alteration. This rule accommodates the silhouette that has a larger waist than seat as compared to standard. Most measurement sets in this rule set would require a waist increase alteration of approximately 1-inch.
- ◆ Rule 5S allows 1 inch less ease than standard in the seat without alteration. Measurement sets within this seat range that fall at the lower limit may require an increase seat alteration. This rule accommodates the silhouette that is the farthest from the standard as compared to all previous rules. Some portion of the measurement sets in this rule range could require an increase alteration for the seat and a reduction alteration at the waist. Note that in the table detailing the rules used to accommodate size issue on the data sets being analyzed, the 5S rule was not used. It is necessary to cover any extremes that may arise. The data used to generate the rules did have a subject that fell in this category. But this should be a very small percentage of the total issues.
- ◆ The range rules allow increase and decrease alterations as necessary to accommodate the balance of the expected spectrum of measurement combinations as compared to the standard that might fall in the normal range. Rule R1 through R3 rules are for the more extreme body measurement combinations.
- ◆ The minus special rule (MSP) rule and the plus special rule (PSP) were included to cover the measurement groups outside the normal measurement ranges.

Rule Code Distribution: May 1999 Scan Data

Rule Code	Quantity	Rule Code	Quantity
1S	34	1R	12
2S	46	2R	4
3S	20	3R	2
4S	32	MSP	2
5S	0	PSP	3

The distribution of size selection by Rule Code was evaluated. There were a total of 155 data sets available. It was determined that 144 of the 155 (93%) of the sizes issued were within the standard alterable range of Rule 1S through Rule 1R. Therefore, a total of 93% of the 155 scans were within the norm expected. Of the remaining 11 data sets, two were discarded due to an initial problem at scanning. Therefore, approximately 95% of the available acceptable subjects were issued by rule 1R and below. Of the balance that were issued with the outer limit rules, all but 2 were issued the same or within +/-1 of the MCRD issue

The size selection rules appear to be issuing appropriately with the test body measurement sets. One criteria used in the generation of the size selection rule table was the number of sizes issued that matched MCRD.

13.0 SCAN DATA COMPARED TO DSCP TARRIFF

13.1 *Marine Corp Men's Dress Coat*

The ARNScan data collected at MCRD, February through May 2000, was combined in a database for review. The database used for evaluation has approximately 2030 measurement data sets with MCRD size issue data as well as ARNScan size issue.

Tarriff data for the Marine dress coat was provided by Defense Supply Center Philadelphia (DSCP). The information provided was based on the average monthly demand for a period of 12 months. The monthly demand was provided as a percentage of the total by chest size and length.

The following table compares the DSCP data, ARNScan size selection data, and MCRD issue data by chest size issued. The table comparison is also provided in bar charts as follows:

- Chart 1 – DPSC, ARNScan, MCRD
- Chart 2 – DPSC, MCRD
- Chart 3 – DPSC ARNScan

Few data were available on sizes 30 through 35 as the table indicates. The analysis indicates that on sizes 36 through 39 DSCP issued a larger percentage than MCRD or ARNScan. For example, on size 36 the percentage issued was; DPSC .0459,

ARNScan .0201, and MCRD .0266. On size 40 MCRD issued the largest percentage of .1667 as compared to DPSC .1507 and ARNScan .1370. Size 41 appears to be close to the same for all three.

The data indicates that on sizes 42 through 48 that MCRD and ARNScan issued significantly more of these sizes than the DPSC data. The barcharts show in an easily identifiable way that the trend was for ARNScan and MCRD to issue a smaller percentage of sizes below 40 and a larger percentage of sizes larger than 40 as compared to DSCP data would indicate being required.

ISSUE DATA COUNT				ISSUE DATA PERCENT		
Coat Size	DSCP DATA	ARNScan DATA	MCRD DATA	DSCP DATA	ARNScan DATA	MCRD DATA
30	5	0	0	0.0038	0.0000	0.0000
32	2	0	1	0.0015	0.0000	0.0005
33	5	2	1	0.0038	0.0009	0.0005
34	4	3	1	0.0031	0.0013	0.0005
35	12	20	7	0.0092	0.0086	0.0036
36	60	47	51	0.0459	0.0201	0.0266
37	97	119	93	0.0742	0.0510	0.0484
38	125	159	165	0.0956	0.0681	0.0859
39	175	260	231	0.1339	0.1113	0.1203
40	197	320	320	0.1507	0.1370	0.1667
41	192	331	251	0.1469	0.1418	0.1307
42	166	354	301	0.1270	0.1516	0.1568
43	128	318	208	0.0979	0.1362	0.1083
44	94	239	185	0.0719	0.1024	0.0964
46	42	155	99	0.0321	0.0664	0.0516
48	3	8	6	0.0023	0.0034	0.0031
Total	1307	2335	1920	1.0000	1.0000	1.0000

Chart 1

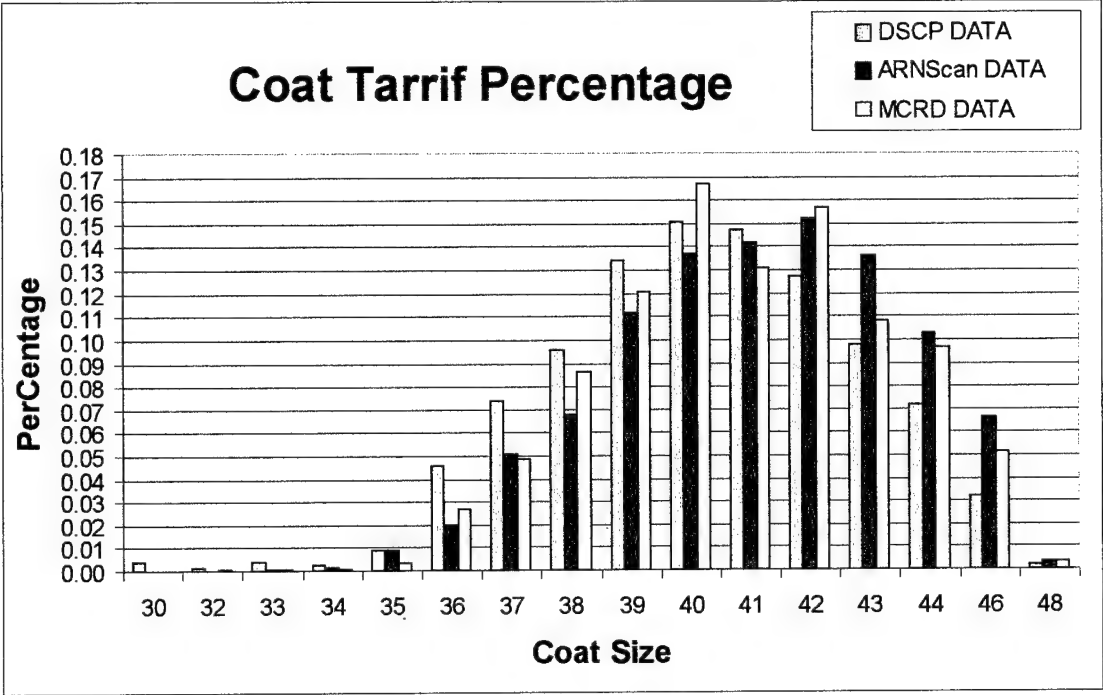


Chart 2

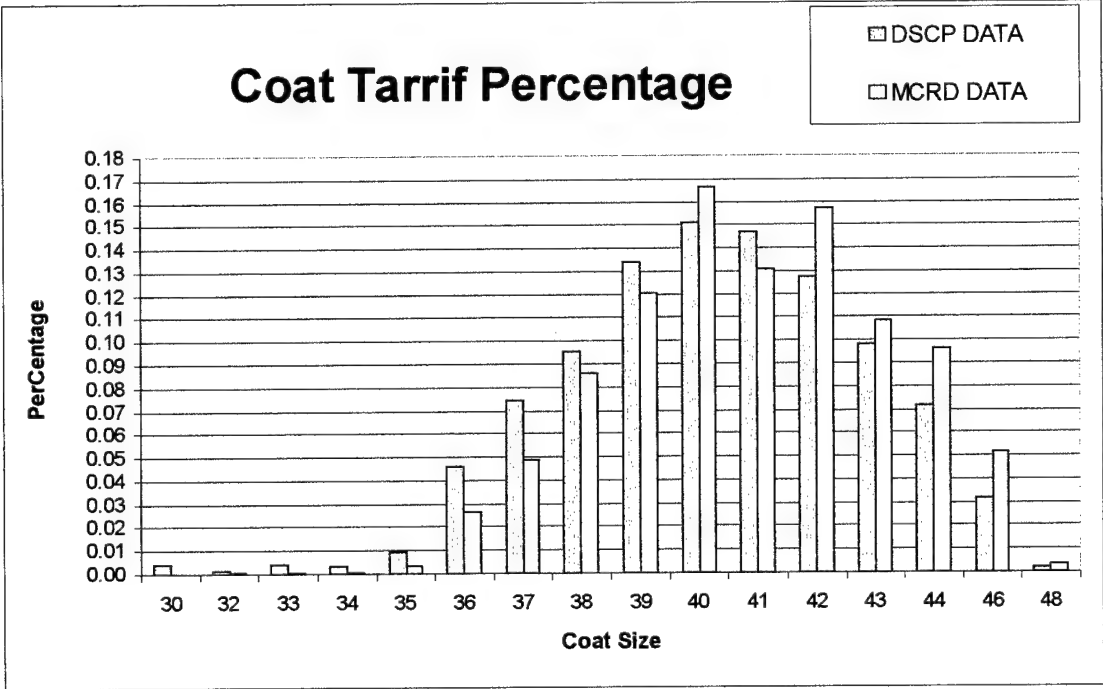
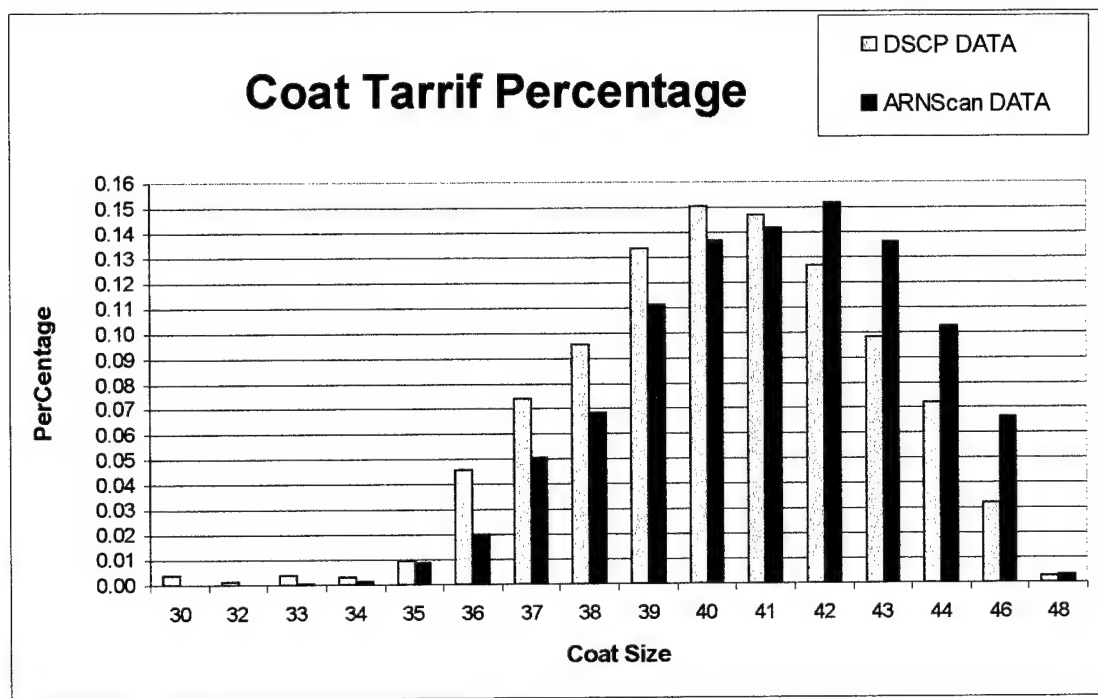


Chart 3



13.2 Marine Corp Men's Dress Trousers

The ARNScan data collected at MCRD, February through May 2000, was combined in a database for review. The database used for evaluation has approximately 2030 measurement data sets with MCRD size issue data as well as ARNScan size issue.

Tariff data for the Marine dress uniform items was provided by Defense Supply Center Philadelphia (DSCP). The information provided was based on the average monthly demand for a period of 12 months. The monthly demand was provided as a percentage of the total.

The following table compares the DSCP data, ARNScan size selection data, and MCRD issue data by trouser waist size issued. The table comparison is also provided in bar charts as follows:

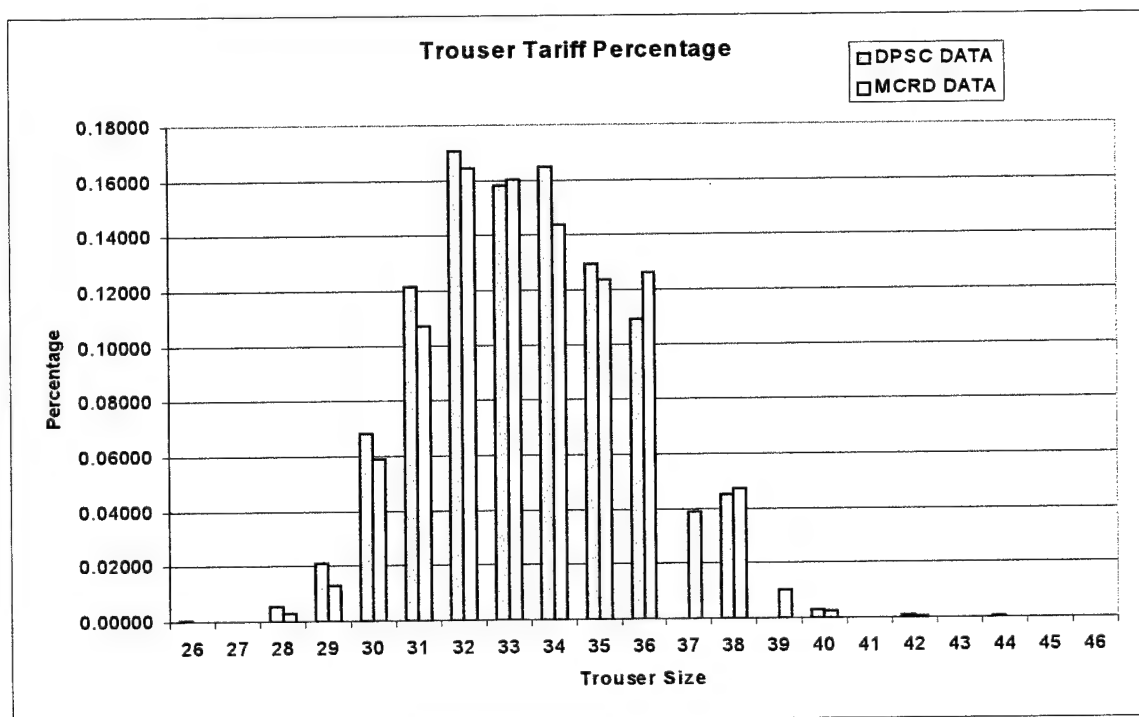
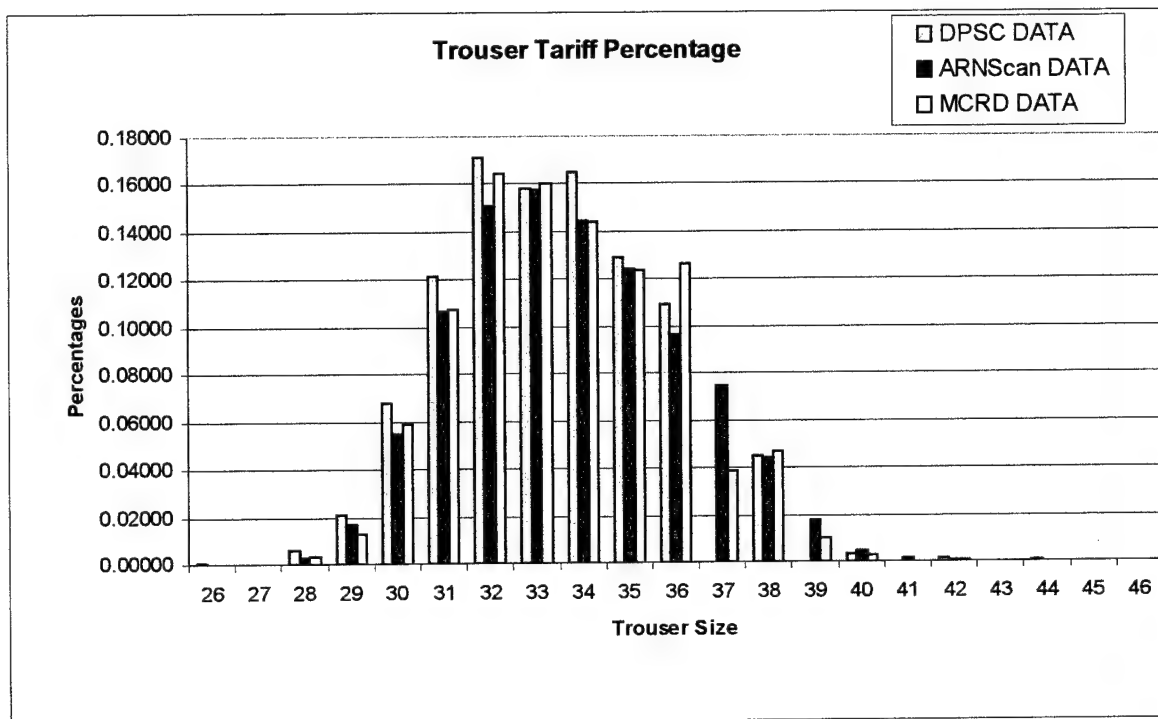
- Chart 1 – DPSC, ARNScan, MCRD
- Chart 2 – DPSC, MCRD
- Chart 3 – DPSC ARNScan

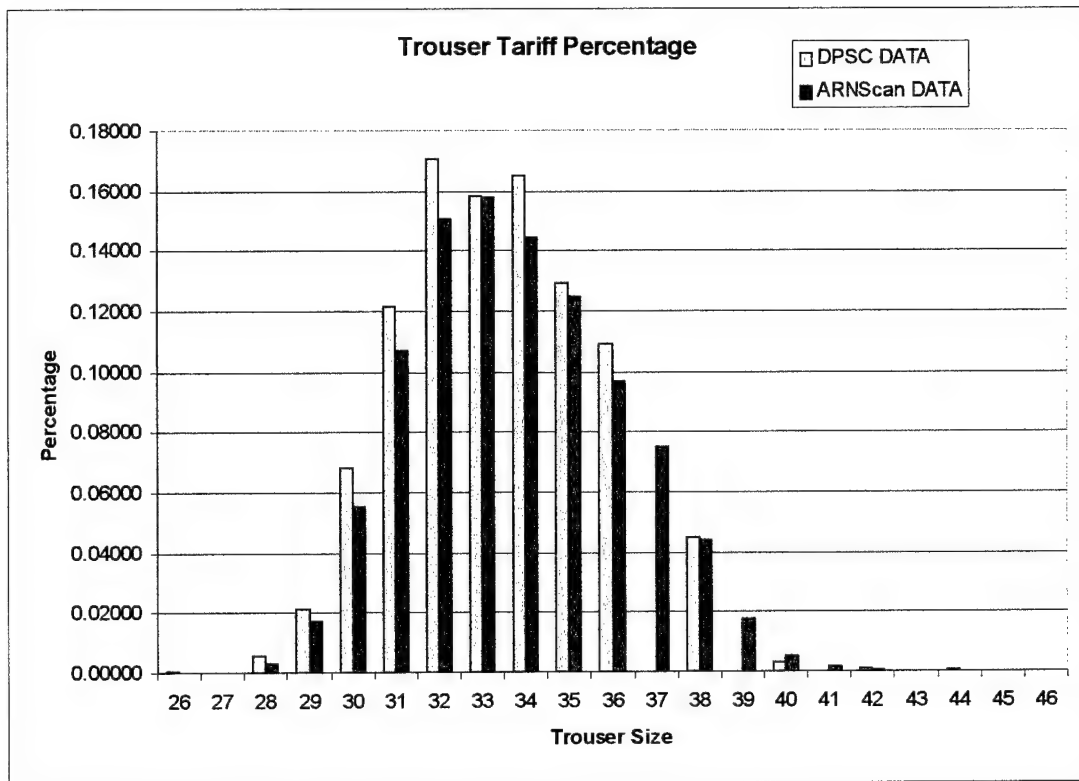
Less than ½ percent of issues were in the waist range 26-27. The largest percentage was in the waist range 28 through 34 as follows: DPSC .7112, ARNScan .6346, and MCRD .6510. As the bar chart indicates, the DPSC percentage of size issue

distribution was higher in 6 of the 7 waist sizes included in this range. Size 35 through 36 distribution was almost even as follows: DPSC .2386, ARNScan .2213, and MCRD .2496. The waist range percentage distribution of 37 through 42 indicates a larger percentage being issued in this range by ARNScan and DPSC as follows: DPSC .0492, ARNScan .1441, and MCRD .0994.

The bar chart shows in an easily identifiable way that the trend was for ARNScan and MCRD to issue a smaller percentage of sizes below 34 and a larger percentage of sizes larger than 37 as compared to MCRD Tariff.

ISSUE	DATA	COUNT		ISSUE	DATA	PERCENT
Trouser Size	DPSC DATA	ARNScan DATA	MCRD DATA	DPSC DATA	ARNScan DATA	MCRD DATA
26	2	0	0	0.00042	0.0000	0.0000
27	0	0	0	0.00000	0.0000	0.0000
28	28	7	6	0.00591	0.0030	0.0031
29	101	40	25	0.02131	0.0170	0.0131
30	323	130	113	0.06814	0.0551	0.0591
31	576	252	205	0.12152	0.1068	0.1073
32	810	355	314	0.17089	0.1505	0.1643
33	750	372	306	0.15823	0.1577	0.1601
34	783	341	275	0.16519	0.1446	0.1439
35	613	294	236	0.12932	0.1246	0.1235
36	518	228	241	0.10928	0.0967	0.1261
37	0	177	74	0.00000	0.0750	0.0387
38	213	104	90	0.04494	0.0441	0.0471
39	0	42	20	0.00000	0.0178	0.0105
40	15	12	5	0.00316	0.0051	0.0026
41	0	4	0	0.00000	0.0017	0.0000
42	5	1	1	0.00105	0.0004	0.0005
43	0	0	0	0.00000	0.0000	0.0000
44	3	0	0	0.00063	0.0000	0.0000
45	0	0	0	0.00000	0.0000	0.0000
46	0	0	0	0.00000	0.0000	0.0000
Totals	4740	2359	1911	1.00000	1.0000	1.0000





13.3 Marine Corp Men's Long Sleeve Shirt

The ARNScan data collected at MCRD was combined in a database for review. The database used for evaluation of tariff has approximately 2030 measurement data sets with MCRD size issue data as well as ARNScan size issue.

Tariff data for the Marine dress uniform items was provided by Defense Supply Center Philadelphia (DSCP). The information provided was based on the average monthly demand for a period of 12 months. The monthly demand was provided as a percentage of the total.

The following table compares the DSCP data, ARNScan size selection data, and MCRD issue data by shirt neck size issued. The table comparison is also provided in bar charts as follows:

- Chart 1 – DPSC, ARNScan, MCRD
- Chart 2 – DPSC, MCRD
- Chart 3 – DPSC ARNScan

Less than 1 percent of issues were in the neck range 13 through 14. The largest percentage was in the neck range 14.5 through 17 as follows: DPSC .9579, ARNScan .9759, and MCRD .9693. Approximately 2% of issues were in the neck range of 17.5 through 18.

Comparison Chart for Neck Sizes 13 - 18

Shirt Size	DPSC DATA	ISSUE DATA COUNT		DPSC DATA	ISSUE DATA PERCENT	
		ARNScan DATA	MCRD DATA		ARNScan DATA	MCRD DATA
13	5	0	1	0.0004	0.0000	0.0005
13.5	5	0	0	0.0004	0.0000	0.0000
14	184	9	10	0.0151	0.0039	0.0052
14.5	673	58	46	0.0551	0.0249	0.0240
15	1927	224	193	0.1578	0.0962	0.1006
15.5	3455	514	433	0.2829	0.2208	0.2256
16	3116	668	544	0.2551	0.2869	0.2835
16.5	1995	568	458	0.1633	0.2440	0.2387
17	534	240	186	0.0437	0.1031	0.0969
17.5	253	37	37	0.0207	0.0159	0.0193
18	67	10	11	0.0055	0.0043	0.0057
Total	12214	2328	1919	1.0000	1.0000	1.0000

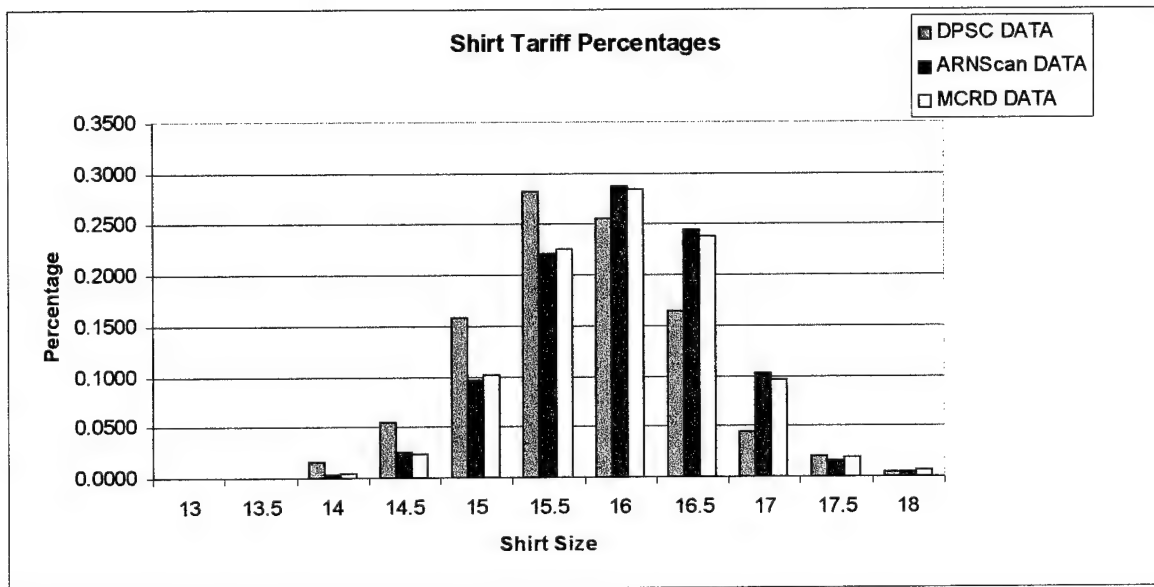
In analysis of the comparison table for percentage of issue by neck size, it is apparent that in the neck range of 14.5 through 17 where the majority of the garments issued are that DPSC tariff is much different than MCRD or ARNScan. The bar chart indicates that DPSC percentage of size issue distribution was much higher in the three smaller sizes within this range, 14.5 - 15.5. The largest percentage is indicated in the following table by red.

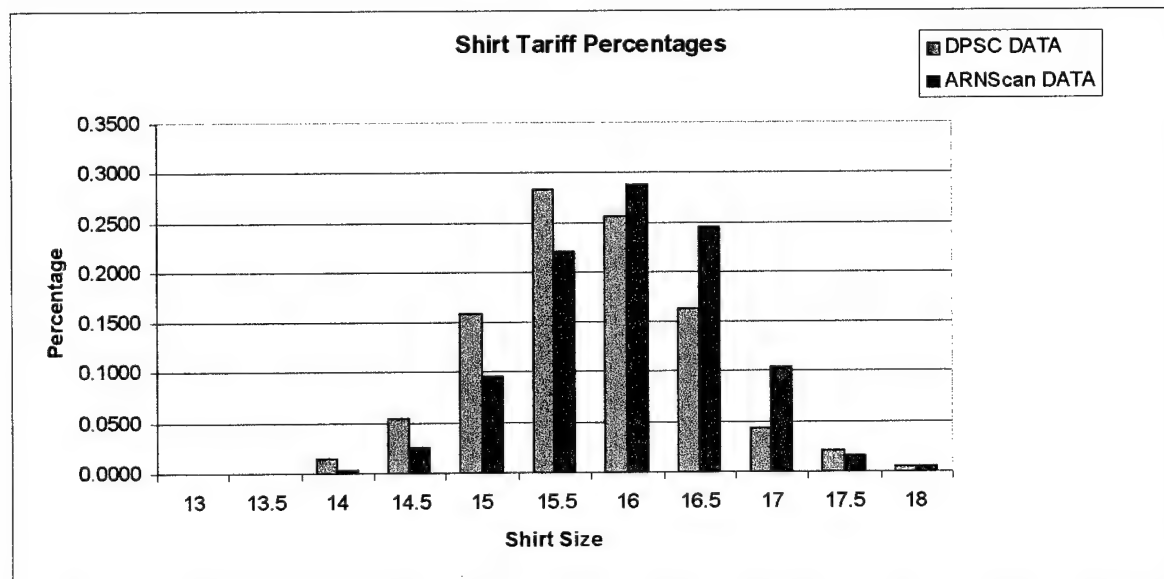
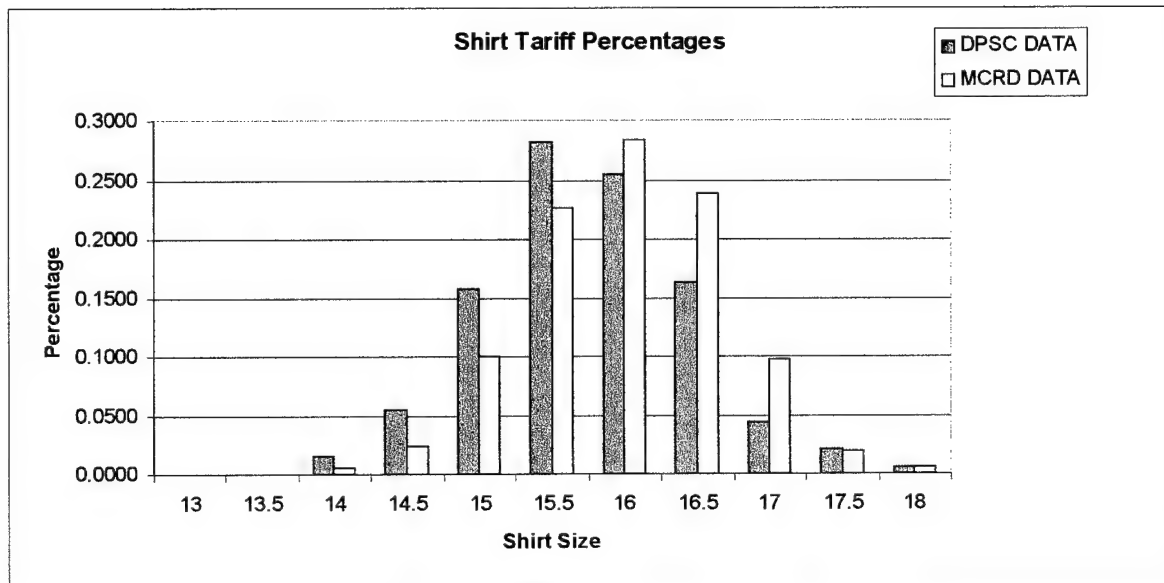
Comparison Chart for Neck Sizes 14.5 - 17

Shirt Size	ISSUE DATA PERCENT		
	DPSC DATA	ARNScan DATA	MCRD DATA
13	0.0004	0.0000	0.0005
13.5	0.0004	0.0000	0.0000
14	0.0151	0.0039	0.0052
14.5	0.0551	0.0249	0.0240
15	0.1578	0.0962	0.1006
15.5	0.2829	0.2208	0.2256
16	0.2551	0.2869	0.2835
16.5	0.1633	0.2440	0.2387
17	0.0437	0.1031	0.0969
17.5	0.0207	0.0159	0.0193
18	0.0055	0.0043	0.0057
Total	1.0000	1.0000	1.0000

The shirt tariff analysis appears to follow the same distribution pattern as the coat and trouser reviewed in previous reports. The shirt distribution barchart shows an easily identifiable pattern when compared to the coat and trouser data comparison charts.

The trend for DPSC tariff percentage to be greater in the smaller sizes for the majority of the issues verses MCRD and ARNScan issuing the greater quantity in the larger sizes has been evident in the coat, trouser, and shirt items. ARNScan approximates the same distribution as MCRD. This would be expected, as the success of ARNScan is determined by the number of times that the issue size matches what is being manually selected by the fitter/tailor. The size selection algorithms were developed taking into consideration the preferred concept of fit at MCRD, San Diego.





14.0 STATISTICAL SIZE ISSUE ANALYSIS

Size issue data has been collected for three main Marine dress uniform items; coat, shirt and trouser. This data is generated by the Cyberware Whole Body Scanner (WBX) which is installed at the Marine Corps Recruit Depot in San Diego. The Size Selection Statistics Tool compares the sizes actually issued with the sizes selected by the ARNScan software. These statistics can be viewed on the Cyberware web site, www.cyberware.com. The sizes of these uniform items have been evaluated by the separate components that represent an actual size such as the coat chest and length.

Each summary lists the measurements used to determine the component size of the selected garment. The determination of what results are considered to be "correct" is based on military design specifications and visual confirmation by an on-site inspector. The size issued and given final approval is documented as well as the size that ARNScan recommended. The comparison of these two sizes is the basis for determining the quantity that ARNScan issued correctly. The size selection summary for a uniform item is based on the summaries of its components. If the component sizes are found to be correct, the size of the uniform item is considered to be correct.

The following tables are the summary statistics posted on the Cyberware site for the scans taken with the WBX scanner January 2000 – December 2000.

Database Summary 2000												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Scans	299	1099	412	371	763	1271	1771	2502	890	1237	1035	602
Platoons	6	23	11	9	20	18	31	37	13	24	19	13
Actual (scans/hr)	47	65	58	58	65	70	68	67	66	68	69	72
Adjusted (scans/hr)	58	80	74	78	83	87	87	91	78	81	84	81
Maximum (scans/hr)	85	112	109	116	116	116	116	120	112	120	116	116
Average (Fits/Hr)	n/a	n/a	n/a	n/a	n/a	128	124	124	124	27	116	124

Item	Correct	% Correct	Incorrect	% Incorrect
Trouser	6595	93.6	452	6.4
Trouser Waist	6725	95.3	334	4.7
Trouser Length	6870	97.4	180	2.6
Shirt	6438	91.2	623	8.8
Shirt Neck	6735	95.2	342	4.8
Shirt Sleeve	6717	95.1	346	4.9
Coat	6007	85.0	1058	15.0
Coat Chest	6728	88.8	795	11.2
Coat Length	6712	94.9	357	5.1

Company: USMC				
Location: San Diego				
	1998	1999	2000	2001
Scans	734	1032	12260	1173
Platoons	32	22	224	27
Actual (scans/hr)	n/a	48	66	70
Adjusted (scans/hr)	n/a	57	83	82
Maximum (scans/hr)	n/a	92	120	116
Average (Fits/Hr)	n/a	n/a	81	116

Trouser	Count	%	Shirt	Count	%	Coat	Count	%
Correct:	6595	93.6	Correct:	6438	91.2	Correct:	6007	85.0
Incorrect:	452	6.4	Incorrect:	623	8.8	Incorrect:	1058	15.0
Trouser Waist	Count	%	Shirt Neck	Count	%	Coat Chest	Count	%
Correct:	6725	95.3	Correct:	6735	95.2	Correct:	6728	88.8
Incorrect:	334	4.7	Incorrect:	342	4.8	Incorrect:	795	11.2
Trouser Length	Count	%	Shirt Sleeve	Count	%	Coat Length	Count	%
Correct:	6870	97.4	Correct:	6717	95.1	Correct:	6712	94.9
Incorrect:	180	2.6	Incorrect:	346	4.9	Incorrect:	357	5.1

15.0 CONCLUSIONS

The Marine Corp dress clothing size selection rules generated and imported into ARNScan are presently being used to issue the first try-on garment at MCRD, San Diego. The tables represented in the statistics section of this report give detailed summaries of the success of the WBX Full Body Scanner and the size selection software.

The implementation of the scanner into the issuing process at MCRD has resulted in fewer incorrectly-sized garments issued, less recruit time consumed, and possible reduction in alterations. The accuracy, consistency and objectivity provided by the system allows for size selection to be more automated and consistent sizing from recruit to recruit.

16.0 APPENDIX

16.1 Measurement Definitions

1. Stature (Height):
Height of the top of the head from the floor.
2. Neck Circumference:
Measured at the shirt collar level and angle.
3. Chest Circumference:
Circumference at the level (height above the floor) of maximum anterior point (front of the breast).
4. Waist Circumference:
Circumference is measured horizontally, immediately above the top of the hip.
5. Seat (Hip) Circumference:
Horizontal circumference at the level of the maximum posterior point on the buttocks.
6. Cross Shoulder:
Cross Shoulder is a surface measurement for the distance between the lateral edges of the shoulders.
7. Sleeve Length:
Starting at the cervical landmark at the base of the neck, then passing over the acromion and down the arm to a point one inch above the base of the thumb.
8. Pant Inseam (Crotch Height):
Floor to the trouser crotch.

16.2 Trouser Garment and Body Measurement Table

MARINE TROUSERS - FINISHED MEASUREMENTS

MIL-T-29452A

BASE

MARINE - SIZE	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
WAIST	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00
SEAT (HIP)	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00	48.00	49.00	50.00	51.00	52.00	53.00	54.00	55.00

MARINE TROUSERS - BODY MEASUREMENTS

BASE

(BODY MEASUREMENTS)

MARINE - SIZE	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
WAIST (1" ease)	25.00	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00
SEAT (3" ease)	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00	48.00	49.00	50.00	51.00	52.00

Finished Inseam Length

WAIST - SIZE	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
X-SHORT (5'0"-5'4")	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
SHORT (5'5"-5'7")	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
REGULAR (5'8"-5'10")	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
LONG (5'11"-6'1")	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
X-LONG (6'2"-UP)	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37

16.3 Coat Garment and Body Measurement Table

MARINE COAT - FINISHED MEASUREMENTS																	MIL-C-29424A	
MARINE - SIZE	30	32	33	34	35	36	37	38	39	40	41	42	43	44	46	48		
CHEST	32.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	48.00	50.00		
WAIST	25.50	27.50	28.50	29.50	30.50	31.50	32.50	33.50	34.50	35.50	36.50	37.50	38.50	39.50	41.50	43.50		
SEAT (HIP)	32.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	48.00	50.00		
ACROSS SHOULDER	15.75	16.25	16.50	16.75	17.00	17.25	17.50	17.75	18.00	18.25	18.50	18.75	19.00	19.25	19.75	20.25		
MARINE COAT - BODY MEASUREMENTS																	BASE	
MARINE - SIZE	30	32	33	34	35	36	37	38	39	40	41	42	43	44	46	48		
CHEST (ease 2")	30.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	46.00	48.00		
WAIST (ease 2 1/2")	23.00	25.00	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	39.00	41.00		
SEAT (ease 2")	30.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	46.00	48.00		
ACROSS SHOULDER (ease 1")	14.75	15.25	15.50	15.75	16.00	16.25	16.50	16.75	17.00	17.25	17.50	17.75	18.00	18.25	18.75	19.25		
MARINE COAT - Back Length																		
MARINE - SIZE	30	32	33	34	35	36	37	38	39	40	41	42	43	44	46	48		
X-SHORT (5'0"-5'4")	27.50	27.75	27.88	28.00	28.13	28.25	28.38	28.50	28.63	28.75	28.88	29.00						
SHORT (5'5"-5'7")	28.50	28.75	28.88	29.00	29.13	29.25	29.38	29.50	29.63	29.75	29.88	30.00	30.13	30.25	30.50			
REGULAR (5'8"-5'10")	29.50	29.75	29.88	30.00	30.13	30.25	30.38	30.50	30.63	30.75	30.88	31.00	31.13	31.25	31.50	31.75		
LONG (5'11"-6'1")	30.50	30.75	30.88	31.00	31.13	31.25	31.38	31.50	31.63	31.75	31.88	32.00	32.13	32.25	32.50	32.75		
X-LONG (6'2"-UP)					32.63	32.75	32.88	33.00	33.13	33.25	33.38	33.50	33.63	33.75	34.00	34.25		
MARINE COAT - Sleeve Inseam																		
MARINE - SIZE	30	32	33	34	35	36	37	38	39	40	41	42	43	44	46	48		
X-SHORT (5'0"-5'4")	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00						
SHORT (5'5"-5'7")	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00			
REGULAR (5'8"-5'10")	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00		
LONG (5'11"-6'1")	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00		
X-LONG (6'2"-UP)					21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50		

16.4 Long Sleeve Shirt Garment and Body Measurement Table

[illegible]